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HAWAIIAN AND OTHER PACIFIC ECHINI.

THE ECHINOTHURIDÆ.

BY

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WITH THIRTY PLATES.

Plates 60–89.

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HAWAIIAN AND OTHER PACIFIC ECHINI.

Collected by the U. S. Fish Commission Steamer "Albatross," Commander Chauncey Thomas, U. S. N., Commanding in 1902, and Lieut. Commander L. M. Garrett, U. S. N., Commanding in 1906.

ECHINOTHURIDÆ Wyv. Thom.

Some Anatomical Features.

Plates 60–63.

Although various writers[1] have discussed the anatomy of the Echinothuridæ in more or less detail, and some have published figures to illustrate certain anatomical peculiarities, it has seemed to be desirable to give a few figures showing the general arrangement of the alimentary canal and the lantern in some of the species, whose anatomy has not hitherto been figured. As our investigations have led us to believe that the Echinothuridæ and Diadematidæ are nearly related families, we have also added a few figures showing the anatomy of several species of Diadematidæ.

A comparison of the figures given on Plates 62 and 63 shows that the genera of Echinothuridæ differ not a little among themselves in the details of their structure. It is, nevertheless, instructive to compare these figures with those of the genera of Diadematidæ given on Plates 60 and 61. The œsophagus, for example, is shortest in Echinothrix (Pl. 60, fig. *3*), somewhat longer in Micropyga (Pl. 61, fig. *1*) and Phormosoma (Pl. 62, fig. *2*), much longer in Echinosoma and Sperosoma (Pl. 62, figs. *3*, *4*), and longest in Asthenosoma (Pl. 62, fig. *1*) and Astropyga (Pl. 61, fig. *3*).

The alimentary canal of Phormosoma is remarkably different from that of Asthenosoma (compare figs. *1* and *2*, Pl. 62), but it is interesting to note that that of Echinosoma (Pl. 62, fig. *3*) is quite intermediate.

[1] Wyville Thomson, 1874: "Porcupine" Echinoidea, Trans. Roy. Soc. London, 164, pt. 2, Pls. LXIII–LXVII. A. Agassiz, 1881: "Challenger" Echinoidea, Pls. XII, XIV, XVIII^{b}. Paul and Fritz Sarasin, 1888: Ergeb. Nat. Forsch. Ceylon, 1, Pls. XII–XVII. Kœhler, 1898: "Hirondelle" Echinides, Pls. IV and IX. Schurig, 1906: Wiss. Ergeb. d. Deutsch. Tiefsee-Exp. 5, lfg. 3, Pls. LI–LIV.

That of Sperosoma (Pl. 62, fig. *4*) shows some noticeable resemblances to the arrangement in Echinothrix (Pl. 60, fig. *3*), though it has certain peculiarities of its own, in addition to the long, slender œsophagus. There can be no question that the general arrangement of the canal in Asthenosoma (Pl. 62, fig. *1*) is quite as near what we find in Astropyga (Pl. 61, fig. *3*) as it is to that of any genus of Echinothurids.

A comparison of the lanterns and perignathic girdles figured on Plate 63 with those of the three genera of Diadematidæ (Pl. 60, fig. *4*; Pl. 61, figs. *2*, *4*) reveals two very important differences. In the Echinothurids, the apophyses, whether conspicuous as in Phormosoma (Pl. 63, fig. *3*), or relatively inconspicuous as in Asthenosoma (Pl. 63, fig. *2*), are single, in keeping with the presence of the single primordial interambulacral plate, while in the Diadematids they are paired. In the Echinothurids (Pl. 63), the Stewart's organs, though very different in appearance from those of the Cidaridæ, are well developed,[1] while in the Diadematids they are either wholly wanting or are reduced to mere rudiments as shown in Echinothrix (Pl. 60, fig. *4*). Aside from these two points, the differences between the girdle and lantern of Phormosoma and those of Asthenosoma are as great as those which distinguish Phormosoma from Astropyga, or Echinothrix from Micropyga. We find there is noticeable individual diversity in certain points, such as the bulk of the auricles and the amount of forking at the end of the compasses, so that these features are of little value in determining generic limits.

The Spines, Pedicellariæ, Sphæridia, and Spicules.

Plates 64–67.

The spines of the Echinothuridæ show so much diversity of form, aside from the differences between primary, secondary, and miliary spines, that they deserve a special paragraph. They may be conveniently classified under four heads, — naked spines, sheathed spines, glandular spines, and hoofed spines. The *naked spines* are the ordinary spines, more or less abundant on all parts of the test; they may be slender or stout, primaries, secondaries, or miliaries; they may be either sharp or blunt, or rarely, widened and flattened at tip, long or short, smooth or rough; they

[1] Those writers who have said that Stewart's organs are rudimentary or wanting in certain Echinothurids have either had poor material or have overlooked these long, slender outgrowths. Or else there is more individual diversity than would naturally be expected.

are rarely verticillate as in Diadema. They are commonly hollow, though some of the very slender ones and those on the buccal membrane are often solid, at least in their distal half. The *sheathed spines* are commonly primary spines, but may be secondaries or even miliaries; when the sheath of skin is thick and loose they are conspicuous and unmistakable, but when the sheath is thin and close-fitting they can scarcely be distinguished from ordinary "naked" spines, which are, of course, really covered by the skin. Sheathed spines may be either actinal or abactinal in position, and the sheath may be either cylindrical or distally swollen; when cylindrical, it may have one or more circular constrictions. The *glandular spines* are secondaries or miliaries, exceedingly sharp, and provided with a poison-gland at the tip. They are commonly abactinal in position, and may be arranged in regular series on the interambulacra. The *hoofed spines* are always actinal primaries, and are the most conspicuous spines on the test when present. They are usually hollow, even the shining white hoof-shaped swelling in which they terminate being only loosely filled with calcareous strands; but in some species the hoof and the distal half of the spine are perfectly solid; there is more or less diversity however in different spines, even of a single individual. Unfortunately the hoofs are very easily broken off, and otherwise good specimens may show few or none. All four of these different kinds of spines may occur on a single individual, but as Mortensen has pointed out, species which have sheathed spines actinally do not have hoofed spines.

The pedicellariæ of the Echinothuridæ have been so fully discussed and satisfactorily figured by Mortensen and Döderlein, it is hardly necessary to devote much space to their description. There are four different sorts, two or more of which may be found in any individual. The *triphyllous* pedicellariæ (Pl. 64, fig. *3*) are always present, and always have three valves, which are broadest at or near the tip and are well separated from each other just below the middle when the pedicellaria is closed; the valves (Pl. 64, figs. *8*, *12*) are provided with a "cover-plate" which is usually more or less perforated. These pedicellariæ are abundant on almost all parts of the test, and are borne on long slender stalks, which are several times as long as the head. The *tridentate* pedicellariæ (Pls. 64, fig. *9*; 66, figs. *1*, *2*, *15*, *17*; 67, figs. *2*, *3*, *4*, *6*, *8*, *9*, *12*, *17*) are nearly or quite as common as the triphyllous, but are very much more diverse in size and form. They occur on all parts of the test, but their abundance varies greatly in different indi-

viduals. The length of stalk is also very variable, though it commonly exceeds that of the head. The structure of the stalk is of the usual type in the Diadematidæ, a cylinder of irregularly but closely united coarse rods. It is very interesting to note that in Kamptosoma the stalk is made up of "long threads, almost only united at the ends" (Mortensen); the stalk in this genus, therefore, bears the same relation to the stalk in other Echinothurids that the stalk of the pedicellariæ in Micropyga does to that of the other Diadematids, — a very notable case of "parallelism." The valves of the tridentate pedicellariæ vary so much in size and form that a general description of them is impracticable, but certain kinds are very constant and easily recognizable, and these deserve a few words. First of all are *involute* valves, which are more or less curved and meet only at tip (Pl. 66, fig. *1*); in these the margins of the blade are rolled in, forming a nearly cylindrical middle part of greater or less length between the base of the blade and the somewhat expanded tip; secondly, there are *contiguous* valves, which are straight and in contact for nearly their entire length, — these may be very broad (Pl. 65, fig. *18*), or rather narrow (Pl. 64, fig. *5*); a third sort may be referred to as *convergent* valves, which are straight or little curved, little or not at all involute, meeting only at tip or for their distal half; such valves are shown on Pl. 65, fig. *5*; see also Pl. 67, figs. *4*, *12*. Although these three sorts of valves are usually recognizable with ease, they do intergrade more or less (Pl. 65, fig. *4*; 66, fig. *2*). The *ophicephalous* pedicellariæ (Pl. 65, figs. *1*, *2*) are much less common, as a rule, than the tridentate, and have been found as yet in only a comparatively few species; they are strongly constricted at the middle, and the articular loops on the valves (Pl. 65, fig. *3*; 67, fig. *21*) are well developed; these pedicellariæ show no tendency to intergrade with the other forms. The fourth form of pedicellaria was first described by Wyville Thomson as a "tetradactyle" pedicellaria, and Mortensen has retained the name. Unfortunately, however, the number of valves is often three or five, so that the "tetra" — is very inappropriate; we would suggest that this form be called simply the *dactylous* pedicellariæ. They are known only from certain species of Aræosoma, and show considerable diversity in the form of the valves; these may be long and slender, united only near the base and quite free distally (Pl. 66, fig. *20*), or they may be much shorter and well surrounded by tissue as de Meijere figures them, or the valves may be wholly imbedded in tissue (Pl. 64, fig. *1*). The valves differ notably in shape (compare Pl. 64, fig. *4*, and

66, fig. *20*) and may even be greatly reduced, with the expanded tip entirely lacking; this form, which occurs in *A. pellucidum*, was at first regarded by Mortensen as a "globiferous" pedicellaria; but he was subsequently satisfied by de Meijere's evidence, that it is simply a degradational form of dactylous pedicellaria. There are no globiferous pedicellariæ known in the Echinothuridæ.

As Döderlein has well pointed out, the three families Aspidodiadematidæ, Diadematidæ, and Echinothuridæ show such agreement in the essential features of their pedicellariæ that they form a group apart from the other regular Echini, and arouse the suspicion that they are mutually interrelated. In the absence of globiferous pedicellariæ (present only in Centrostephanus) they agree with the Salenidæ and Arbaciadæ, and differ markedly from the Cidaridæ, Echinometridæ, and Echinidæ. Their mutual agreement in tridentate pedicellariæ is obvious, but in view of the great diversity of form which these pedicellariæ show in the three families, and of the fact that very similar pedicellariæ occur in other families, no great weight can be laid on this point. The ophicephalous pedicellariæ of the Echinothuridæ are peculiar but are as much like those of the Diadematidæ as of any other echini, excepting only some of the spatangoids. The triphyllous are similar to those of the Aspidodiadematidæ; they are less like those of Astropyga and Micropyga, but still the resemblance even here is not to be ignored.

The *sphæridia* of the Echinothuridæ (Pls. 66, figs. *4, 5, 18;* 67, fig. *11*), as in the Aspidodiadematidæ and many Diadematidæ, are more or less numerous in each ambulacrum and occur at the inner lower side of the tube-feet in the innermost series. In Phormosoma they are also present next to the feet of the middle series. They may be confined to the actinal surface of the test, but commonly they extend above the ambitus. They sometimes accompany the tube-feet nearly or quite to the ocular plate, and occasionally they may be found on the buccal plates. In Phormosoma they are nearly spherical, but in the other genera they are more or less elongated; sometimes the length and appearance (Pl. 66, fig. *18*) indicate clearly their origin as modified spines.

The *calcareous spicules* of the tube-feet are commonly in the form of perforated plates (Pl. 65, figs. *14, 20*), which show great diversity in form and size. In some species, however, the spicules, either in the basal part of the foot or throughout its length, are simply more or less irregular triradiate rods (Pl. 66, fig. *13*), similar to those found in the Diadematidæ. There

seems no reason to question the fundamental triradiate origin of even the larger perforated plates, so that we have here again a suggestion of Diadematid relationship.

The Systematic Position of the Echinothuridæ.

In all discussion as to the proper position of the Echinothuridæ in our classification of the Echini, the crucial point is as to the stress that shall be laid on the occurrence of regular series of ambulacral plates on the actinostome. If this character is regarded as of fundamental importance, then of course the Echinothurids stand quite apart from all the other regular Echini, excepting only the Cidaridæ; but if the possibility be admitted that this character has appeared independently in the Echinothurids, or has been retained by them, while lost by the other families, then we may well examine with care the other characters of the family to see if we cannot ascertain its relationships.

Mortensen is one of those who hold to the fundamental importance of the Echinothurid actinostome, and has expressed himself (1904) as favoring their union with the Lepidocentridæ in a suborder (Streptosomata) apart from the other Ectobranchiate Regulares. Döderlein, on the other hand, has expressed himself (1906) as believing in the close relationship of the Echinothurids and Diadematids, and he recognizes a suborder (Diadematida) which includes the Streptosomata as a special "tribe" containing the Echinothurids only and the Stereosomata, a tribe made up of the Diadematidæ and its closest allies. In attempting to reach a correct conclusion on the question, it has seemed to us that it would be helpful to tabulate in parallel columns all the morphological characters of the Echinothuridæ and Diadematidæ. By so doing the similarities and differences will be made to stand out more vividly, and we may perhaps be able to decide whether the resemblances indicate relationship or not. The characters are arranged in what seems to us to be the order of importance.

The careful comparison of the ambulacra in Echinothrix, Astropyga, Micropyga, Phormosoma, Asthenosoma, and Sperosoma demonstrates that the differences are superficial, and that in all these genera each ambulacral plate consists of three elements, of which the middle one (primary) is largest, while the adoral and aboral (secondary) elements show great diversity in size and position. In Echinothrix the secondary elements are rather large and lie next to the interambulacrum; the pore-pair of the

TABLE OF THE MORPHOLOGICAL CHARACTERS OF THE ECHINOTHURIDÆ AND DIADEMATIDÆ.

	Diadematidæ.	Echinothuridæ.
Structure of Ambulacra.	Diadematoid; each compound plate consists of a middle primary, and abactinal and actinal secondary elements. Adoral imbrication usually slight or wanting.	Essentially diadematoid; some diversity shown in relative size and position of plate-elements. Adoral imbrication usually well-marked.
Interambulacral Areas.	Interambulacral plates bevelled on edge.	Interambulacral plates imbricating.
	Primordial interambulacral plate resorbed. Aboral imbrication not usually noticeable. Without evident membranous interspaces.	Primordial interambulacral plate retained. Aboral imbrication more or less marked. Membranous interspaces often very marked.
Primary Tubercles.	Perforated; usually crenulated.	Perforated; non-crenulated.
Abactinal System.	Large; anal system covered by numerous small plates; anal tube often present; commonly 2–5 oculars in contact with anal system; genito-ocular ring continuous, with rare exceptions; genital plates seldom split.	Large; anal system covered by numerous small plates; anal tube wanting; all oculars in contact with anal system; genito-ocular ring often discontinuous; genital plates often split.
Actinostome.	With five pairs of buccal plates and more or less numerous small scattered plates, either confined to, or much more conspicuous in the ambulacral areas.	Covered by five double columns of perforated ambulacral plates.
Teeth.	Grooved.	Grooved.
Jaws.	More or less erect, with open foramen magnum.	More or less inclined, with open foramen magnum.
Perignathic Girdle.	Continuous; auricles and apophyses more or less extensively developed.	Continuous; auricles and apophyses more or less extensively developed.
Arrangement of Tube-feet.	In three longitudinal series, commonly; sometimes in two; rarely in one actinally.	In one, two, or three longitudinal series.
Spines.	Hollow; long, usually verticillate, sometimes smooth; hoofs and conspicuous skin-sheaths wanting.	Hollow; short, usually smooth and very rarely verticillate; hoofs or conspicuous skin-sheaths often present, at least on actinal primaries.
Stewart's Organs.	Rudimentary or usually wanting.	Well-developed; rarely rudimentary, and possibly wanting in some individuals.
Gills.	Well-developed.	Commonly well-developed.
Alimentary Canal.	Long and large; œsophagus long and more or less coiled.	Long and large; œsophagus long and more or less coiled.
Pedicellariæ.		
Globiferous.	Wanting (except Centrostephanus).	Wanting.
Ophicephalous.	Valves constricted at middle; blade deeply hollowed, with little calcareous material within.	Valves very wide near tip and deeply constricted, essentially as in Diadematidæ.
Triphyllous	Flat and leaf-shaped, commonly without cover-plate.	Flattened and widened at tip, with cover-plate.
Tridentate.	Very diverse, both large and small.	Very diverse, both large and small.
Tube-feet.	With sucking disc actinally, but usually not abactinally.	No sucking disc abactinally, and often not actinally.
Sphæridia.	Usually numerous, not sunken in pits, arranged in a vertical series, at inner side of inner series of tube-feet, in each half ambulacrum.	As in Diadematidæ.
Calcareous Spicules.	Essentially triradiate, often forming perforated plates.	Usually perforated plates, often showing triradiate origin; sometimes triradiate spicules.
Color.	Usually very dark, black, olive, purple, or red; sometimes light; spines often banded.	Deep purple, red, dull yellowish, gray, or greenish; spines often banded.
Size.	Usually large, up to 150 mm. h. d.	Large, 70–320 mm. h. d.

primary element is the outermost of the three, that of the adoral secondary is innermost, while that of the aboral secondary is intermediate; we thus get the characteristic arrangement of the pore-pairs in arcs of three. In Astropyga, only the alternate primary elements are like each other in form, one series being broadest at the inner end, and those alternating with them broadest at the middle; the secondary elements accompanying the latter occupy the same position they do in Echinothrix, while those which accompany the plates with a wide inner end lie close to that end; the pore-pairs of the primary elements are here median in position, while the pore-pairs of the secondary elements alternate, two pairs being inner, then two outer, then two inner, etc. The characteristic arcs of three are thus maintained. In Micropyga the elements are arranged essentially as in Echinothrix, but the pore-pairs of the primaries alternate in position, as well as those of the secondaries (as in Astropyga); thus, if the pore-pair of a given primary element lies at the outer end of the plate, the pore-pairs of the secondary elements of the same plate occupy a median position, while in the adjoining plates the pore-pairs of the primary elements will be median in position and those of the secondary elements take an outside position; we thus get the double column of pore-pairs characteristic of Micropyga. In most of the Echinothuridæ the condition is essentially as in Echinothrix, but the secondary plate elements remain so small and are so generally pushed out of position, the appearance of an ambulacrum is quite different from that of any Diadematid; the abactinal arrangement of the pore-pairs is commonly as in Echinothrix. In Sperosoma, the secondary plate elements become so large actinally, they separate the inner half of the primary element from the outer, and there thus appear to be *four* columns of plates in each half-ambulacrum. Mortensen says, in his diagnosis of Sperosoma, "The secondary ambulacral plates on the actinal side of the same size as the primary ones." We do not find this to be the case in the type-species, *Grimaldii*, nor in any other of the species we have examined; it seems to us that the halves of the primary element are, with rare exceptions, noticeably larger than the secondary elements.

The difference between the Echinothuridæ and Diadematidæ in the imbrication of the coronal plates is one of degree and not of kind, and the same is true of the presence of membranous interspaces between the plates. The difference between the test of an Echinothrix or Centroste-

phanus and that of an Astropyga or Micropyga is fully as great in these particulars as that between Astropyga and such Echinothurids as *Araeosoma Owstoni* or *A. thetidis.* In fact the resemblances between the two families in the general character of the test are far more weighty than are the differences. The crenulation of the primary tubercles is generally marked in the Diadematidæ, but it is quite wanting in Micropyga and Lissodiadema, in which genera the tubercles are like those of the Echinothurids.

The abactinal system of the Echinothurids represents merely an extreme condition of the Diadematid form. There is really no difference of importance between the arrangement of the plates in some species of Aræosoma and that which we find in Astropyga and Chætodiadema. When the abactinal system of Leptodiadema is compared with that of some species of Echinosoma the differences are most striking, but when we examine other genera we can trace every step of the transition from one into the other.

As regards the actinostome, it must be admitted that the fully plated buccal membrane of the Echinothurids is quite unlike anything to be found in the Diadematidæ. As Döderlein has well pointed out, we may regard the plating as a character developed in the Echinothuridæ independently, an interesting parallelism with what is found in the Cidaridæ and some Palæozoic Echini, or we may look on it as a heritage, from some ancestral form, which the Diadematidæ have lost. The actinostomal plates of the Diadematidæ, aside from the customary buccal ten, are usually numerous and often abundant. And it is interesting, if not important, to note that in nearly all Diadematids these plates are confined to, or at least are much more abundant in, the ambulacra, and sometimes form a double column in each ambulacrum. In Astropyga it is these ambulacral plates which carry the pedicellariæ, and in young specimens what appear to be rudimentary tube-feet are sometimes present; we have never found any visible perforation of the plates, however. We incline to the view, nevertheless, that the condition of the actinostome in the Diadematids indicates the gradual loss of ambulacral plates similar to those of the Echinothurids.

The teeth, jaws, and perignathic girdle in the two families are so similar, we have not found any important constant difference. The jaws are decidedly more inclined in the Echinothurids than in Diadema, but Astro-

pyga and Micropyga are intermediate in this respect. The lantern of Astropyga is surprisingly like that of *Asthenosoma Ijimai.* There is great individual diversity in both families in the amount of calcification in the perignathic girdle. In some specimens the auricles are very moderate and the apophyses almost wanting, while in others the auricles are enormous and the apophyses stout.

In the internal anatomy the two families are much alike, except that the Echinothuridæ have well-developed Stewart's organs and longitudinal body-wall muscles, both of which are rudimentary or wanting in the Diadematidæ. The Stewart's organs are undoubtedly a heritage, and their form would seem to indicate that they now have little functional importance. The body-wall muscles have doubtless been developed in connection with the increasing mobility of the test. The gills of the two families and the sphæridia show the greatest similarity.

The spines are fundamentally alike in their structure, commonly hollow, though not infrequently more or less solid, at least near tip. They are much longer in many Diadematidæ than in the Echinothuridæ, but Astropyga and Micropyga are more like the latter family. The presence of poison-tipped spines is a character found in both families, but hoofs and skin-bags seem to belong to the Echinothuridæ exclusively. It should be noted, however, that Döderlein has figured spines in Dermatodiadema, which are so formed as to almost warrant their being called "hoofed," and somewhat similar spines occur in Micropyga. Some of the spines of Echinothrix, moreover, might almost be called "sheathed." Such special modifications of the spines cannot be regarded as of great weight in estimating relationships.

The similarities between the two families in their pedicellariæ have been referred to above; they have also been discussed quite fully by Döderlein. The fundamental resemblance of the spicules in the tube-feet is noteworthy, though they are much more fully developed in most Echinothuridæ than in the Diadematids. In color and size the similarity between the two families is more noticeable than the difference. The banding of the primaries, so marked in young Diademas, is noticeable in some Asthenosomas. The Diadematidæ and the shallow-water Echinothurids are tropical and particularly East Indian forms. The deep-water Echinothurids have spread both north and south of the tropics.

In view of all these facts, we find ourselves driven to the opinion that

the relationship between the Echinothuridæ and Diadematidæ is very close. We cannot believe that the many points of resemblance are either coincidences or examples of parallelism. On the other hand, it seems clear that many of the differences, such as those in the abactinal system and test, are due to the increased size of the Echinothurids accompanied by decrease in calcification. The relationship between Astropyga and Micropyga on the one hand and Aræosoma on the other is very close; were it not for the difference in the actinostome they would certainly be regarded as belonging in a single family. The recognition of a separate suborder (Streptosomata) for the Echinothuridæ, based on the flexibility of the test, seems to us quite unnecessary. The test of several Echinothurids is little or no more flexible than that of Astropyga and Micropyga, and it is certainly an exaggeration of the differences between these genera and the Echinothuridæ to place them in different suborders. The Aspidodiadematidæ, Diadematidæ, and Echinothuridæ form a natural group with some interesting primitive characters, and if suborders of the Diadematoida are to be recognized they should certainly form one together.

The Genera and Species of Echinothuridæ.

The Echinothuridæ are a fairly homogeneous and well-defined group, the limits of which are so clear that there has never been any question raised as to whether a given recent species were an Echinothurid or not. For many years, only two genera (Phormosoma, Asthenosoma) were recognized, but in 1897 Kœhler described a new form (Sperosoma), the actinal ambulacra of which are quite unique. In 1903 Mortensen split the family into ten genera, and suggested the possibility of two more; while he gave attention to the structure of the test, his classification was based chiefly on the characters furnished by the spines and pedicellariæ, especial emphasis being placed on the latter. Three of his genera (Calveria, Hapalosoma, Tromikosoma) are based almost exclusively on the pedicellariæ, and he has suggested in later writings that they might not be maintained, a suggestion in which we fully concur. Mortensen says "it is the spines, the pedicellariae, the tube-feet, and the spicules which bear the principal part in the new classification of the Echinothurids." "Of course also the structure of the test is always of importance, but the all predominant importance that has hitherto been attached to the form and mutual relation of the plates will have to be very much reduced." — "The arrangement of the

plates is generally only to be seen in dried specimens. But the Echinothurids are only very little adapted for preservation in dried state, and if the material in hand be slight, one does not like to destroy it for the sake of determination." — "The sphæridiæ . . . show no differences so great that they can be of any systematic importance. The pedicellariæ, on the other hand, are of the greatest importance with regard to the classification." It is because we do not think that the "spines, the pedicellariæ, the tube-feet, and the spicules" should "bear the principal part" in a satisfactory classification of the Echinothurids, and because we consider "the structure of the test," using that phrase in the widest sense, to be of "all predominant importance" that we are obliged to dissent from Mortensen's classification. Moreover, we find the Echinothurids admirably adapted "for preservation in dried state"; all of the photographic plates given herewith and those in the report on the Panamic deep-sea Echini (Mem. M. C. Z., XXXI) are from dried specimens; so far from drying, destroying the specimens, it prepares them very satisfactorily for systematic study. As will be noted in our discussion of the genus Phormosoma, we find the sphæridia afford an interesting character of real "systematic importance."

Our studies of the Echinothuridæ have led us to the conclusion that there are six natural genera in the family. We believe Mortensen is right in limiting Phormosoma to the group of species allied to *placenta*, but we fail to find any character of importance by which his genera Hygrosoma and Tromikosoma are to be distinguished from Echinosoma Pomel. Of course, if one considers the possession of certain peculiar pedicellariæ, in small numbers, by some individuals, as a valid generic character, then one must accept Mortensen's groups, but, as we have often stated, we cannot believe such a criterion is right. The peculiar ambulacra of Kamptosoma and Sperosoma warrant the recognition of those genera, while the numerous, small, uniform primary tubercles, bearing sheathed spines, which cover the abactinal surface of Asthenosoma, make that genus, as limited by Mortensen, an easily recognized group. We have not been able to find any satisfactory characters by which Mortensen's genera Hapalosoma and "Calveria" are to be distinguished from Aræosoma, and we have therefore united the three groups under the last name.

The six genera which are thus accepted by us may be distinguished from each other as follows:

Actinal tube-feet in a single (or rarely two) more or less irregular series.
- Primary ambulacral plates throughout most of ambulacra accompanied, each by two secondary poriferous elements.
  - Many actinal primary spines enclosed in skin-bags, none with hoofs; abactinal and actinal surfaces strikingly and abruptly unlike . . . . *Phormosoma.*
  - Actinal primary spines not enclosed in skin-bags, some at least ending in hoofs; abactinal and actinal surfaces not strikingly and abruptly unlike . . . . *Echinosoma.*
- Primary ambulacral plates, each accompanied by a single secondary element or none . . . . *Kamptosoma.*

Actinal tube-feet in three more or less distinct series.
- Each half of an ambulacrum, actinally, consists of a column of wide low primary plates, each accompanied by two small secondaries.
  - Abactinal surface covered by numerous small primary tubercles none of which are conspicuously larger than the others; abactinal primary spines encased in loose skin-sheaths . . . . . . *Asthenosoma.*
  - Abactinal surface with at least 30 conspicuous primary tubercles; abactinal primary spines not encased in loose skin-sheaths . . . *Aræosoma.*
- Each half of an ambulacrum, actinally, consists of four columns of plates, the two median columns made up of the secondary plate-elements, the inner column made up of the inner halves of the primary plates, the outer column, of the outer halves . . . . *Sperosoma.*

PHORMOSOMA.

Wyville Thomson, 1872. Proc. Roy. Soc. Edinburgh, VII, 84, p. 617.
Type-species, *Phormosoma placenta* Wyville Thomson, l. c.

It seems to us desirable to accept Mortensen's limitation of this genus, as the group is well defined and easily recognized. The test is rather rigid, with actinal side markedly different from abactinal. The actinal primary tubercles and areolæ are large, while the loose skin-sheaths of the spines are very characteristic. We beg to call attention to the arrangement of the nearly spherical sphæridia, an interesting generic character overlooked by Mortensen but which seems to be very constant. They are present actinally on both secondary elements of each primary plate. Of course one occasionally finds a secondary plate-element actinally which has no sphæridium, but it is usually clear that the absence is accidental. In all other Echinothurids, only the inner (lower) secondary element carries a sphæridium. This genus, as now limited, contains eight recognizable species, but they are closely related to each other and the lines of separation are not distinct. Both Mortensen (1903) and Döderlein (1906) are inclined to regard *rigidum* A. Ag. as a synonym of *placenta*, in spite of its great geo-

graphical separation from that species. The size and arrangement of the abactinal pores are so different from what is found in specimens of *placenta* of the same size as the type of *rigidum*, that we think it better to keep the latter separate, at least until more material is available. Döderlein considers a form of *placenta* which he calls *Sigsbei* recognizably distinct from *placenta* proper, because of fewer and higher abactinal coronal plates. Mortensen (1907) finds that this difference is not constant, but believing the tridentate pedicellariæ of true *placenta* to differ from those of "*Sigsbei*," he thinks the latter may be a recognizable variety. Examination of a considerable series of specimens of both *P. placenta* and *P. bursarium* has satisfied us that in those two species, the height, and consequently the number, of coronal plates is subject to considerable individual diversity not associated with definite localities, and that the tridentate pedicellariæ are also very variable. Specimens from the same or adjoining stations have very different pedicellariæ; the best illustration of this is found in two specimens of *bursarium* from Stations 5082 and 5084; the specimen from 5082 has only short and thick tridentate pedicellariæ, while in the one from 5084 these pedicellariæ are longer and more slender than in any Phormosoma we have seen. It may be well to add that other specimens are intermediate between these two extremes. In view of these facts, we do not think that the form to which Döderlein and Mortensen refer can well be distinguished, but we are now satisfied that *P. Sigsbei* is really as valid a species as most of those in the genus, if we recognize others than *placenta*. The name was originally applied to the Phormosoma collected by the "Blake" west of the Lesser Antilles. Subsequently this form was considered identical with the Phormosoma collected off the eastern coast of the United States, and all were determined as *P. placenta*. Recent examination of the Caribbean specimens, and comparison with large numbers of Phormosoma from both the Atlantic and Pacific Oceans, have led us to believe that they are distinct from *placenta* and somewhat nearer *bursarium*. We have decided therefore to revive the name *Sigsbei* for them; if the American form of *placenta*, usually having short, thick pedicellariæ and relatively few coronal plates is to be distinguished from the European form, a new name must be given to it. In this connection it may be well to state that a renewed examination of the specimens of young Phormosomas, the figures of which ("Blake" Echini, Pl. XV) are criticised by Mortensen ("Ingolf" Ech., Pt. I, p. 69), has satisfied us that those figures are essentially correct.

Mortensen dismisses the possibility of the differences between his specimens and these figures being specific, by saying he has had specimens from the Gulf of Mexico which are exactly like those from Davis Strait, where his young specimens were taken. This is interesting as confirming our opinion that the Lesser Antillean species is distinct, and also as showing that *placenta* extends its range as far southwestward as the Gulf of Mexico.

The eight species of Phormosoma which we here recognize may be distinguished from each other as follows:

Primary tubercles of ambulacra, abactinally, very much smaller than those of interambulacra and arranged in four vertical series . . . . *alternans.*
Primary tubercles of ambulacra, abactinally, not conspicuously smaller than those of interambulacra.
  Abactinal primary spines rough with minute teeth which are in whorls on distal part of spine . . . . *verticillatum.*
  Abactinal primary spines smooth, or at least never verticillate.
    Abactinal primary tubercles small and rather numerous (300–500), occurring on all or nearly all the coronal plates.
      Ambulacral pores large, in a nearly vertical series at extreme outer end of ambulacral plates, abactinally . . *rigidum.*
      Ambulacral pores smaller, in more oblique arcs of three abactinally, and not at extreme outer end of plates.
        Actinostome small (less than .30 h. d.), little larger than abactinal system . . . . *adenieum.*
        Actinostome more than .30 h. d., distinctly larger than abactinal system . . . . *placenta.*
    Abactinal primary tubercles larger and less numerous (70–300), wanting on many of the upper coronal plates.
      Abactinal arcs of pores few and nearly vertical, rarely exceeding ten even when there are nine interambulacral plates . . . . *Sigsbei.*
      Abactinal arcs of pores 12–25, quite oblique.
        Abactinal primary tubercles few (70–150), large, confined to peripheral half of test . . . . *indicum.*
        Abactinal primary tubercles more numerous (150–300), smaller, not confined to peripheral half of test . . . . *bursarium.*

Phormosoma alternans de Meij.

Phormosoma alternans de Meijere, 1903. Tijdschr. Ned. Dierk. Ver., (2) VIII, p. 2. 1904. Ech. "Siboga" Exp., Pls. III, figs. *21, 22*; XII, figs. *143–148*.
Dutch East Indies; 386 fathoms.

Although this species is known from only a single specimen (very dark brown, 52 mm. in diameter), it seems to be better characterized than any of the other species recognized as distinct from *placenta*. Its general facies, both with and without the spines, would seem to be quite different from that

of any other species, but further material is necessary to determine how constant these characters are and what are the limits of their variation.

Phormosoma verticillatum Mortens.

Phormosoma verticillatum Mortensen, 1904. Ann. Mag. Nat. Hist. (7) XIV, p. 90; Pls. IV, figs. *1, 2;* V, figs. *15–17.*

Bay of Bengal; 678 fathoms.

In addition to the characteristic verticillated abactinal spines, Mortensen points out the small actinal and abactinal systems as features in which this species differs from *placenta;* thus the abactinal system of a *placenta,* 66 mm. h. d., is about 30 % h. d., while in *verticillatum,* 63 mm. h. d., it is only about 20. The color of *verticillatum* may prove to be a good character, for although the specimens are bleached, there is some indication of violet actinally, not a common color in the genus.

Phormosoma rigidum A. Ag.

Phormosoma rigidum A. Agassiz, 1881. "Challenger" Ech., p. 104; Pl. XIIa, figs. *1–4.*

Off New Zealand; 700 fathoms.

Although the specimens on which this species is based are small, the largest only 40 mm. h. d., the abactinal ambulacral pores are quite characteristic, and we do not think they can wisely be referred to either *placenta* or *bursarium*

Phormosoma adenicum Död.

Phormosoma adenicum Döderlein, 1905. Zool. Anz. XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XV, figs. *3, 3a;* XXXVIII, figs. *4a–h.*

Gulf of Aden; 816 fathoms.

In addition to the characters given above, this species has an unusual number of abactinal ambulacral plates, in comparison with the number of abactinal interambulacral plates. Thus, in Döderlein's larger specimen (55 mm. h. d.) there are 17 ambulacral and 10 interambulacral plates abactinally, while in *placenta* of the same size there are 10–15 and 7–11 respectively; in *adenicum,* the abactinal interambulacral plates are less than .60 of the ambulacral, while in *placenta* they are .70–.75. Possibly the color may be a good specific character, for Döderlein says his specimens appear to have been dark red.

Phormosoma placenta Wyv. Thom.

Phormosoma placenta Wyville Thomson, 1872. Proc. Roy. Soc. Edinburgh, VII, 84, p. 617. 1874. "Porcupine" Ech., Trans. Roy. Soc. London, 168, pt. 2, Pls. LXII and LXIII, figs. *1–8*.

North Atlantic, from Davis Strait to Gulf of Mexico on the west and from Iceland to 3° N. on the east; 235–1389 fathoms.

This species is so well known, we need add nothing here to the descriptions and figures which have already been published.

Phormosoma Sigsbei A. Ag.

Phormosoma Sigsbei A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 75. 1883. "Blake" Ech., Mem. M. C. Z., X, Pls. XII; XV, figs. *3–19*.

Eastern Caribbean Sea; 120–573 fathoms.

This species is in life reddish-orange, pinkish abactinally; preserved specimens are decidedly pinkish-purple when not bleached. Wyville Thomson says *placenta* is gray flecked with purple; preserved specimens are yellowish-brown, sometimes very dark, often more or less bleached. There is no doubt that this species lives in shallower water, ordinarily, than does *placenta;* the latter is most common at depths ranging from 400 to 1000 fathoms, while *Sigsbei* is found chiefly between 150 and 400 fathoms. The difference in temperature range is even more noticeable, for, while *placenta* is found only in cold water, 37°–41°, *Sigsbei* occurs in water ranging from 40° to 63°, but averaging about 50°.

Phormosoma indicum Död.

Phormosoma indicum Döderlein, 1905. Zool. Anz., XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XV, figs. *1, 2;* XXXVIII, figs. *2–2c, 3–3c*.

Indian Ocean, coasts of Africa and Sumatra; 257–543 fathoms.

The large size of the abactinal primary tubercles and areolæ is very notable, as they are nearly or quite twice the diameter of those in *placenta* and *bursarium*. The color of this species is rather variable, ranging from yellow to dark brown, commonly lighter above than below, and often with a reddish tinge.

Phormosoma bursarium A. Ag.

Phormosoma bursarium A. Agassiz, 1881. "Challenger" Ech., p. 99; Pl. Xb. East Indies; off Japan; Hawaiian Islands; 165–1050 fathoms.

Plates 62, fig. *2;* 63, fig. *3.*

This is the Pacific representative of *placenta,* and very near it in all essential characters. The difference in tuberculation of the test abactinally seems to be fairly constant, but certain specimens of the two forms approach each other very nearly. The color of *bursarium* appears to be quite uniformly yellow-brown, though the shade varies a great deal; some specimens are very dark, while others are bleached almost white; one of the latter is very decidedly pink on the actinal surface. This species was taken by the "Albatross" at the following stations, the specimens ranging from 20 to 110 mm. in diameter:

Station 3884. Between Maui and Molokai, Hawaiian Islands. Bott. temp. 44°. 284–290 fathoms. Glob. m.

Station 3892. Off north coast of Molokai, H. I. Bott. temp. 42.5°. 328–414 fathoms. Fne. gy. s.

Station 3904. Off north coast of Molokai, H. I. Bott. temp. 43.9°. 295 fathoms. Br. m., s., r.

Station 3957. Vicinity of Laysan Island, H. I. Bott. temp. 53.5°. 173–220 fathoms. Fne. wh. s.

Station 3988. Off Hanamaulu, Kauai, H. I. Bott. temp. 40°. 165–469 fathoms. Gy. for. s., p.

Station 3994. Off Mokuaeae Islet, Kauai, H. I. Bott. temp. 42.9°. 330–382 fathoms. Fne. gy. s., for.

Station 3997. Off Ukula Point, Kauai, H. I. Bott. temp. 41°. 418–429 fathoms. Fne. gy. s., br. m.

Station 4019. Off Hanamaulu, Kauai, H. I. Bott. temp. 37.8°. 409–550 fathoms. Gy. s., for., r.

Station 4022. Off Hanamaulu, Kauai, H. I. Bott. temp. 41.° 374–399 fathoms. Co., s., for., r.

Station 4025. Off Mokuaeae Point, Kauai, H. I. Bott. temp. 44.9°. 275–368 fathoms. Fne. gy. s., brk. sh., for.

Station 4087. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.6°. 306–308 fathoms. Fne. gy. s.

Station 4089. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 297–304 fathoms. Fne. gy. s.

Station 4091. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 306–308 fathoms. Fne. gy. s.

Station 4110. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.3°. 449–460 fathoms. Gy. s.

Station 4111. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40°. 460–470 fathoms. Fne. s., r.

Station 4112. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.5°. 433–447 fathoms. Fne. s.

Station 4113. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.6°. 395–433 fathoms. Co., for., s.

Station 4141. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 437–632 fathoms. Vol. s., for.

Station 4906. Southwest of Koshika Islands, Japan; 31° 39′ N., 129° 20′ 30″ E. Bott. temp. — 369–406 fathoms.

Station 4907. Southwest of Koshika Island; 31° 39′ 30″ N., 129° 24′ E. Bott. temp. 42.6°. 406 fathoms. Gy. glob. oz.

Station 4911. Southwest of Koshika Islands; 31° 38′ 30″ N., 129°. 19′ E. Bott. temp. 41.9°. 391 fathoms. Gy. glob. oz.

Station 4912. Southwest of Koshika Islands; 31° 39′ 40″ N., 129° 20′ E. Bott. temp. 41.9°. 391 fathoms. Gy. glob. oz.

Station 4913. Southwest of Koshika Islands; 31° 39′ 10″ N., 129° 22′ 30″ E. Bott. temp. 41.9°. 391 fathoms. Gy. glob. oz.

Station 4914. Southwest of Koshika Islands; 31° 33′ N., 129° 26′ 30″ E. Bott. temp. 41.9°. 427 fathoms. Gy. glob. oz., brk. sh.

Station 4915. Southwest of Koshika Islands; 31° 31′ N., 129° 25′ 30″ E. Bott. temp. 41.9°. 427 fathoms. Gy. glob. oz., brk. sh.

Station 4957. Between Kagoshima and Kobe, Japan; 32° 36′ N., 132° 25′E. Bott. temp. 39.8°. 437 fathoms. Gn-br. m., fne. gy. s., for.

Station 4968. Between Kobe and Yokohama; 33° 24′ 50″ N., 135° 38′ 40″ E. Bott. temp. 45.7°. 253 fathoms. Dk. gy. s., br. m., brk. sh.

Station 4969. Between Kobe and Yokohama; 33° 23′ 40″ N., 135° 33′ E. Bott. temp. 38.9° 587 fathoms. Br. m., s., st.

Station 5078. Off Omai Saki Light, Japan; 34° 12′ 20″ N., 138° 2′ 30″ E. Bott. temp. 38.9°. 475–514 fathoms. Fne. gy. s., glob.

Station 5082. Off Omai Saki Light; 34° 5′ N., 137° 59′ E. Bott. temp. 37.7°. 662 fathoms. Gn. m., fne. s., glob.

Station 5084. Off Omai Saki Light; 34° N., 137° 49′ 40″ E. Bott. temp. 36.8°. 918 fathoms. Gn. m., fne. s., glob.

Station 5086. Sagami Bay, Hondo Island, Japan; 35° 8′ 15″ N., 139° 20′ E. Bott. temp. 43.7. 292 fathoms. Gn. m., crs. bk. s.

Station 5088. Sagami Bay; 35° 11′ 25″ N., 139° 28′ 20″ E. Bott. temp. 41.8°. 369–405 fathoms. Gn. m.

Bathymetrical range, 165–918 fathoms. Extremes of temperature, 53.5°–36.8°.

One hundred and eighty-four specimens.

Echinosoma.

Pomel, 1883. Class. Méth. Ech., p. 108.

Type-species, *Phormosoma tenue* A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 202. (Including Hygrosoma and Tromikosoma Mortensen.)

In this genus, the thin and flexible test has the larger spines and areolæ on the actinal side, but the contrast with the abactinal is not marked. The hoofs of the actinal primaries are usually large and shining white. The sphæridia are more or less elongated and are present only on the inner (lower) secondary plate-element. Although it is not difficult to distinguish the genus from the preceding, the species of which it is composed are exceedingly hard to diagnose in such a way as to make them generally recognizable. No less than 11 different forms have been described and named which certainly belong in Echinosoma, but some of these are of doubtful standing. We are unable to distinguish *mordens* de Meij. from *tenue* A. Ag., or *æthiopicum* Död. from *luculentum* A. Ag. Döderlein himself says that the latter is "sehr nahe" *æthiopicum*, but he distinguishes them by means of the stout, broad-valved, tridentate pedicellariæ which are present in *luculentum* and wanting in *æthiopicum*. In view of the fact that the presence or absence of a given form of pedicellariæ has been shown, in numerous cases, to be a matter of individual diversity only, we cannot consider *æthiopicum* a valid species. Moreover, *hispidum* and *zealandiæ* are very near *tenue*, and *panamense* and *Petersii* are very near *uranus*. Finally, the line between *hoplacantha* and *luculentum* is not as sharp as could be wished. There seems little reason to doubt that *hoplacantha*,

tenue, and *uranus* are good species, but the others herein recognized are of less certain validity. The nine accepted species are to be distinguished from each other as follows:

Tube-feet abactinally in three series; valves of large tridentate pedicellariæ strongly involute at middle.
- Abactinal ambulacral plates only two or three times as numerous as actinal; abactinal spines small and numerous . . . . . . *hoplacantha.*
- Abactinal ambulacral plates four-seven times as numerous as actinal; abactinal primaries long and conspicuous, secondaries and miliaries few . . . . *luculentum.*

Tube-feet abactinally in one or two series.
- Abactinal surface sparsely covered with spines, rarely more than two primary or large secondary tubercles on a plate; secondaries and miliaries not abundant.
  - Abactinal coronal plates rather high, 11–14 in a specimen 125 mm. h. d.; tridentate pedicellariæ with slightly involuted valves *hispidum.*
  - Abactinal coronal plates lower and more curved, 14–16 in specimens 100–125 mm. h. d.; valves of tridentate pedicellariæ not involute at all . . . . *tenue.*
- Abactinal surface more or less thickly covered with spines, often three or more large tubercles on a plate; secondaries and miliaries often abundant.
  - Ambulacra distinctly broader than interambulacra. . . . *Kœhleri.*
  - Ambulacra not broader than interambulacra.
    - Actinostome very large, exceeding .35 h. d., with deep buccal slits . . . . *zealandiæ.*
    - Actinostome not so large, buccal slits slight.
      - Whole test thickly tuberculated; actinal primary tubercles rather small, in vertical series of 6–8 extending nearly to actinostome . . . . *panamense.*
      - Test not so thickly tuberculated; actinal primary tubercles in vertical series of 3–6, confined to peripheral half of actinal surface.
        - Valves of tridentate pedicellariæ rather flat, not involute near middle . . . . *uranus.*
        - Valves of tridentate pedicellariæ strongly involute at middle, and more or less curved . . . . . *Petersii.*

Echinosoma hoplacantha A. Ag. and Cl.

Phormosoma hoplacantha Wyville Thomson, 1877. Voy. "Challenger," Atlantic, I, p. 148.

Phormosoma hoplacantha A. Agassiz, 1881. "Challenger" Ech., Pls. XI; XII; XIIa, figs. *10–13.*

Hygrosoma hoplacantha Mortensen, 1903. "Ingolf" Ech., I, p. 59.

Pacific and Indian Oceans; 402–1375 fathoms.

This is not only one of the largest (312 mm. h. d.) of the Echinothuridæ, but it is one of the most easily recognized for the numerous, slender spines

of the abactinal surface, with primary spines in the ambulacra nearly or quite to the ocular plates, combined with the three distinct rows of abactinal tube-feet, give it a characteristic appearance. The color of the test is dark violet, sometimes with a reddish cast, the spines are dark, often almost black, but the hoofs are pure white. The specimen collected by the "Valdivia" and described by Döderlein differs so much in color from the usual condition that one cannot avoid the suspicion that it may not be this species, and a careful comparison of the photographs given with Japanese specimens of *hoplacantha* strengthens this feeling. Döderlein is doubtful whether de Meijere's *hoplacantha* is not rather *æthiopicum*, as he thinks the pedicellariæ figured are nearer the latter species. After examination of Döderlein's photographs, de Meijere's drawings, and numerous pedicellariæ, we find ourselves driven to this conclusion, — many specimens have some very large pedicellariæ (A. Agassiz, 1881, "Challenger" Ech., Pl. XLIII, fig. *1;* Döderlein, 1906, "Valdivia" Ech., Pl. XXXIX, fig. *3d*), and these specimens all writers call *hoplacantha ;* other specimens, equally well preserved, do not have such large pedicellariæ, but do have very short, stout ones, with widely expanded valves (A. Agassiz, l. c., Pl. XLIV, figs. *25, 26 ;* Döderlein, l. c., Pl. XXXIX, fig. *1a*), and these specimens are called *luculentum*. Other equally good specimens have neither of these characteristic forms, and these specimens de Meijere calls *hoplacantha*, and Döderlein, *æthiopicum*. For our part, we consider the absence of either of these characteristic pedicellariæ as a matter of individual diversity and not a specific character, and we therefore believe de Meijere's identification is correct. Döderlein considers de Meijere's figure *159* ("Siboga" Ech., Pl. XIII) more like the valve of a large tridentate pedicellaria of *æthiopicum*, than it is like one of *hoplacantha*, but it seems to us that de Meijere's outline sketch is quite as near Döderlein's figure *3a* (l. c., Pl. XXXIX) as it is to his figure *2c*.

This species was taken by the "Albatross" at the following stations, the specimens ranging from 20 to 170 mm. in diameter:

Station 4928. In Colnett Strait, Japan; 29° 51′ N., 131° 2′ 30″ E. Bott. temp. 36.8°. 1008 fathoms. Gy. s. glob.

Station 4956. Between Kagoshima and Kobe, Japan; 32° 32′ N., 132° 25′ E. Bott. temp. 37.5°. 720 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 4957. Between Kagoshima and Kobe, Japan; 32° 36′ N., 132° 23′ E. Bott. temp. 39.8°. 437 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 4958. Between Kagoshima and Kobe, Japan; 32° 26′ 20″ N.,

132° 24′ 30″ E. Bott. temp. 40.1°. 405 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 4973. Between Kobe and Yokohama, Japan; 33° 24′ 15″ N., 135° 30′ 30″ E. Bott. temp. 38.2°. 600 fathoms. Bn. m., st.

Station 4980. Between Kobe and Yokohama, Japan; 34° 9′ N., 137° 55′ E. Bott. temp. 39°. 507 fathoms. Bn. m., fne. s., for.

Station 5078. Off Omai Saki Light, Japan; 34° 12′ 20″ N., 138° 2′ 30″ E. Bott. temp. 38.9°. 475–514 fathoms. Fne. gy. s., glob.

Station 5080. Off Omai Saki Light, Japan; 34° 10′ 30″ N., 138° 40′ E. Bott. temp. 38.7°. 505 fathoms. Fne. gy. s., glob.

Station 5082. Off Omai Saki Light, Japan; 34° 5′ N., 137° 59′ E. Bott. temp. 37.7°. 662 fathoms. Gn. m., fne. s., glob.

Station 5084. Off Omai Saki Light, Japan; 34° N., 137° 49′ 40″ E. Bott. temp. 36.8°. 918 fathoms. Gn. m., fne. s., glob.

Station 5086. Sagami Bay, Japan; 35° 8′ 15″ N., 139° 20′ E. Bott. temp. 43.7°. 292 fathoms. Gn. m., crs. bk. s.

Bathymetrical range, 292–1008 fathoms. Extremes of temperature, 43.7°–36.8°.

Thirteen specimens.

Echinosoma luculentum A. Ag. and Cl.

Phormosoma luculenta A. Agassiz, 1879. Proc. Am. Acad., XIV., p. 201.

Phormosoma luculentum A. Agassiz, 1881. "Challenger" Ech., p. 97; Pls. IX; X; Xa, figs. *3–7*.

Hygrosoma luculentum Mortensen, 1903. "Ingolf" Ech., I, p. 59.

Hygrosoma æthiopicum Döderlein, 1905. Zool. Anz. XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp. Pls. XVI; XVII, fig. *2*; XXXIX, figs. *1–2f*.

We are so fortunate as to have before us a small specimen of *æthiopicum* from "Valdivia" Station 246. A careful examination of this specimen, in connection with Döderlein's description and figures, leads us to believe that the form cannot properly be distinguished from *luculentum*, for as already stated we do not consider the absence of the short, thick pedicellariæ a valid specific character. We are even suspicious of the validity of *luculentum* itself, for we shall not be surprised if this species proves to be simply a form of *hoplacantha*. The differences that have been pointed out in either the test or the pedicellariæ do not seem to us very weighty, and their constancy has yet to be proven.

Echinosoma hispidum Mortens.

Phormosoma hispidum A. Agassiz, 1898. Bull. M. C. Z. XXXII, p. 77. 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, Pls. XXX–XLIX.
Echinosoma hispidum Mortensen, 1907. "Ingolf" Ech., Pt. II, p. 24.

Gulf of Panama, west to the Galapagos Islands and north to the Gulf of California; 995–1421 fathoms.

Plates 62, fig. *3*; 63, fig. *4*; 67, figs. *4–11*.

The pedicellariæ of this species are numerous and variable, but we have found only tridentate and triphyllous ones, no ophicephalous. Mortensen ("Ingolf" Ech., II, p. 25) says he has found "a kind of ophicephalous pedicellariæ." Examination of several good specimens, with hundreds of pedicellariæ, has not enabled us to find this form, so we conclude it must be quite exceptional. The triphyllous pedicellariæ are abundant and not peculiar, though the neck may be twice or three times as long as the head (Pl. 67, fig. *10*), and the stalk three or four times as long as the neck; the valves are .40–.50 mm. long and the width at the tip is rather more than half the length.

The *tridentate* pedicellariæ appear in at least four different forms, but they integrade with each other to such an extent it is not easy to draw lines between them. The largest ones (Pl. 67, fig. *4*) are tolerably common; the valves (fig. *5*) are 3–4.75 mm. long, slightly curved, widened at tip, and meet only for the terminal quarter; the edges of the blade are slightly involute, while the centre is occupied by more or less of a calcareous mesh-work. The stalk of these pedicellariæ is scarcely as long as the head, and there is almost no neck. A more abundant form of tridentate pedicellaria is decidedly smaller (Pl. 67, fig. *6*), has the stalk two or three times as long as the head and there is a short neck; the valves (fig. *7*) are straight, 1–1.75 mm. long, not widened at tip or involute at sides, and meet for their whole length. In another form (Pl. 67, fig. *8*), which seems to be very rare, the valves are narrow, nearly straight, a trifle widened at tip, and meet for about three-fourths of their length. They are 1–1.25 mm. long. A fourth form (Pl. 67, fig. *9*), which is also rare, is the smallest of all, but has a long, thick neck and a stalk three to five times as long as the head; the valves are only .35–.75 mm. long, straight, somewhat expanded at tip, and meet for nearly their entire length.

The *sphæridia* (Pl. 67, fig. *11*) are slightly elongated and seem to be

most abundant near the ambitus, though they may occur far up on the abactinal surface. The *calcareous particles* in the tube-feet are small and not very abundant, irregular, perforated plates.

Echinosoma tenue Pomel.

Phormosoma tenuis A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 202.
Phormosoma tenue A. Agassiz, 1881. "Challenger" Ech., p. 91; Pls. XIII, XIV, et al.
Echinosoma tenue Pomel, 1883. Class. Méth. Ech., p. 108.

Pacific Ocean; 1875–2750 fathoms.

Plate 67, figs. *12–21.*

The specimens before us, collected by the "Albatross," show that unless there is some mistake in the labels, this species has an astonishing bathymetrical range. We have compared most carefully the specimens from Stations 3784, 4928 and 5084 with one of the co-types of *tenue* from "Challenger" Station 237, and we find they agree so perfectly in all details that it is impossible to doubt their identity. The specimen from 3707, on the other hand, is small (about 30 mm. h. d.) and more or less damaged, and the original label has the station number so faint that it has been repeated in lead pencil, and in this repetition there is chance for error; Stations 3710, 3711, 3712, and 3736 were the only Japanese stations occupied by the "Albatross" in 1900 where this species would be expected to occur. This small specimen has the tube-feet arranged as in *tenue*, so far as they can be made out, and the pedicellariæ, so far as may be judged from a very few examples, are like those of *tenue.* We therefore believe that the identification of the specimen is correct, but we do not believe it was taken at Station 3707. The color of the specimens before us is varied; the "Challenger" specimen is yellowish, with strong indications of violet actinally, and has light-colored tube-feet; one of the specimens from 3784 is also somewhat yellowish, especially abactinally, but the tube-feet are dark violet in striking contrast; the other specimens range from light to dark violet without a trace of yellow on the test, but in some cases the tube-feet are brownish-yellow. The color of both test and feet seems to depend on the extent to which the bright violet pigment is developed.

The arrangement of the tube-feet, abactinally, in *tenue,* is characteristic when well marked, but there is some individual diversity. In the "Challenger" specimen there are two series closely approximated to each other, on each side of the ambulacrum; in the outer series there are practically

twice as many feet as in the inner, each foot in the latter series being opposite alternate feet in the former; in the inner series, small primary or large secondary tubercles alternate with the feet, so that, while the outer series consists of feet only, the inner consists of alternating tubercles (spines) and feet. In the specimens from 3784 this arrangement is very evident, but it is not quite so clear as in the "Challenger" specimen, because the feet are larger and nearer together vertically. In the specimens from 4928 and 5084, it is not at all noticeable, because the tube-feet are small, light colored, and rather far apart vertically.

The pedicellariæ of *tenue* are not very characteristic, for while they show no little diversity, no one form is really distinctive. Ophicephalous pedicellariæ are numerous on the abactinal surface just above the ambitus in one of the specimens from 4928 and in one of those from 5084; a few were also found in the second specimen from 4928 and one in the second (smaller) specimen from 5084; in the "Challenger" specimen and in the two fine individuals from 3784 there are none. The occurrence of ophicephalous pedicellariæ seems to be, therefore, an individual and not a specific character. Tridentate and triphyllous pedicellariæ are abundant and more or less variable.

The *triphyllous* pedicellariæ (Pl. 67, fig. *19*) have very slender stalks, with the neck of variable length, usually several times as long as the head. The valves (Pl. 67, figs. *15*, *20*) are rather broad, about half as wide at the tip as they are long, or a little wider; they are usually somewhat truncate at the tip, but those on the specimens from 3784 are often more rounded (fig. *15*); they are about half a millimeter long.

The *tridentate* pedicellariæ (Pl. 67, figs. *12*, *17*) vary greatly in size and more or less in form. In the larger ones the neck is short and the stalk is only a little longer than the head, while in the smaller ones the neck may equal the head and the stalk be several times as long. In the largest the valves (Pl. 67, figs *13*, *16*) may be 2.5 mm. long; they are straight, usually meet for their full length, and the sides of the blade are more or less nearly parallel and not at all involute; the blade is more or less filled with a calcareous mesh-work, and the apophysis usually extends into the blade as a serrate median ridge. In the specimens from 3784 the large pedicellariæ are quite variable, and in many of them the valves are separate at the base (see Pl. 67, fig. *12*) for a greater or less distance; the valves are also more or less constricted at the base of the blade and

the apophysis fails to extend into it (fig. *13*). The smaller tridentate pedicellariæ are not peculiar; the valves (Pl. 67, figs. *14*, *18*) are about .40 mm. long and closely in contact throughout, usually they are more or less pointed (fig. *18*), but many of those on the specimens from 3784 are rounded (fig. *14*). Perhaps it ought to be emphasized that the tridentate pedicellariæ integrade with each other in form as well as in size, and the specimens from 3784 have the ordinary forms as well as the more unusual forms figured.

The *ophicephalous* pedicellariæ resemble those of Sperosoma. The stalks are very long, five or six times as long as the head, straight and relatively stout. There is almost no neck. The valves (Pl. 67, fig. *21*) are about .70 mm. long, strongly constricted near the middle and have large articulating loops.

This species was taken by the "Albatross" at the following stations, the specimens ranging from 30 to 135 mm. in diameter.

Station 3707 (?). Off Ose Zaki, Honshu Island, Japan. 63–75 fathoms. Vol. s., a., g.

Station 3784. North of Aleutian Islands; 54° 32′ N., 178° 31′ E. 850 fathoms.[1] Gn. m., fne. gy. s.

Station 4928. In Colnett Strait, Japan; 29° 51′ N., 131° 2′ 30″ E. Bott. temp. 36.8°. 1008 fathoms. Gy. s., glob.

Station 5084. Off Omai Saki Light, Japan; 34° N., 137° 49′ 40″ E. Bott. temp. 36.8. 918 fathoms. Gn. m., fne. s., glob.

Bathymetrical range, 63–1008 fathoms; probably 850–1008 fathoms is correct.

Eight specimens.

Echinosoma Kœhleri A. Ag. and Cl.

Tromikosoma Kœhleri Mortensen, 1903. "Ingolf" Ech., I, p. 78; figs. *5*, *6*.
Davis Strait, 1435 fathoms.

In addition to the extraordinary width of the ambulacra, the abactinal arrangement of the tube-feet is an interesting character of this species; for the inner series contains twice as many feet as the outer, just the reverse of the condition found in *tenue*.

[1] The depth as published in the "Albatross" Records is 85 fathoms. But on the label with these specimens, it is distinctly "850 fms." The "85" is doubtless a misprint.

Echinosoma zealandiae A. Ag. and Cl.

Phormosoma zealandiae A. Agassiz, 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, p. 105; Pl. LI, figs. *1–4*.

Off New Zealand; 700 fathoms.

As the specimen on which this species is based is extremely young (24 mm. h. d.), it is difficult to differentiate it clearly from the other members of the genus. Like *Phormosoma rigidum*, from the same station, it must await further material before having its true status determined beyond doubt.

Echinosoma panamense Mortens.

Phormosoma panamense A. Agassiz, 1898. Bull. M. C. Z., XXXII, p. 77. 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, p. 101; figs. *145–148*.
Echinosoma panamense Mortensen, 1907. "Ingolf" Ech., II, p. 24.

Off Gulf of Panama; 1823 fathoms.

Plate 67, figs. *1–3*.

The pedicellariæ of this species are remarkably short and stout and show little diversity of form.

The *tridentate* pedicellariæ (Pl. 67, figs. *2*, *3*) are all of essentially the same structure, but differ considerably in size. Mortensen ("Ingolf" Ech. II, p. 24) says he has not found the large form of tridentate pedicellaria in *panamense;* as we have also failed to find this form, it probably does not occur in this species. The form which is common, has very wide valves, rounded or bluntly pointed at the tip, in contact for their whole length; the necks are longest in the small ones and may be very short in large ones; the stalk only equals the head in large ones, but is four or five times as long as the head in small ones. The valves range from .35 to 1 mm. in length, and the width is two-thirds of the length or even more. In form the valves are almost exactly like those of the Echinothurid which we have called *Sperosoma biseriatum* (see Pl. 65, fig. *18*), but the blade is often wider at the tip, the sides being nearly parallel.

The *triphyllous* pedicellariæ (Pl. 67, fig. *1*) are common and show little diversity. The stalk is about four times as long as the neck and the latter is equal to, or usually exceeds, the head. The valves are like that shown on Plate 65, fig. *19*.

The *calcareous particles* in the tube-feet are perforated plates of varying size and form, but in general like those shown on Plate 65, fig. *20*. They are commonly larger and more abundant than in *hispidum*.

Echinosoma uranus Pomel.

Phormosoma uranus Wyville Thomson, 1877. Voy. "Challenger," Atlantic, p. 146; figs. *33*, *34*.
Echinosoma uranus Pomel, 1883. Class. Méth. Ech., p. 108.
North Atlantic, 1000–1525 fathoms.

The difference between the tridentate pedicellariæ of this species and the next is marked and can be easily detected with a hand lens, but whether it constitutes a specific difference seems to us open to question. Aside from the characteristic pedicellariæ, this species is very near the following and we shall not be surprised if further material proves that the two are identical.

Echinosoma Petersii A. Ag. and Cl.

Phormosoma Petersii A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 76. 1883. "Blake" Ech., Mem. M. C. Z., X, Pls. X, XI.
Hygrosoma Petersii Mortensen, 1903. "Ingolf" Ech., I, p. 59.
North Atlantic, particularly Caribbean region; 647–1224 fathoms.

As stated above, we are not wholly satisfied as to the validity of this species, but are inclined to let it stand for the present. Mortensen (op. cit., p. 59) says that the tube-feet abactinally are in "three series very close together." Plate X and Plate XI, fig. *1*, of the "Blake" Echini seem to confirm the statement. The true condition is shown in Plate XI, fig. *5*, of the "Blake" report, where it will be seen that the arrangement really is in two series. When a specimen is compared with *hoplacantha* and *tenue*, it is obviously nearer *tenue*, but in large specimens, the feet may become so crowded that the tendency towards three series is evident.

Kamptosoma.

Mortensen, 1903. "Ingolf" Ech., I, p. 60.

Type-species, *Phormosoma asterias* A. Agassiz, 1881. "Challenger" Ech., p. 104.

The rather thin and delicate test has the actinal side quite different from the abactinal in the form of the plates but not in the size of spines or tubercles. Few of the primary ambulacral plates are accompanied by secondary plate elements and never by more than a single one. The sphæridia are carried on the primary plates actinally but may be on secondary plates abactinally. The stalk of the pedicellariæ is made up of loosely connected calcareous threads. This remarkable genus appears to be confined to the deep parts of the southern Pacific Ocean, having been met with hitherto

only by the "Challenger." Its relationship to the other Echinothuridæ is still unsettled and more material is greatly to be desired. There is an interesting parallelism between this genus and Micropyga in the structure of the stalks of the pedicellariæ; each is the only genus in its family with these stalks noticeably different in structure from those found in the allied genera.

There appear to be two quite distinct species of Kamptosoma which may be separated from each other as follows:

Abactinal ambulacral areas not noticeably expanded just above ambitus, composed of high plates not wider than those of the actinal side, their width not exceeding twice their height and sometimes not equalling it . . . . *asterias.*
Abactinal ambulacral areas markedly expanded just above ambitus, composed of low plates, much wider than those of the actinal side, their width often four times the height . . . . *indistinctum.*

Kamptosoma asterias Mortens.

Phormosoma asterias A. Agassiz, 1881. "Challenger" Ech., p. 104; Pl. XII[a], figs. *7–9.*
Kamptosoma asterias Mortensen, 1903. "Ingolf" Ech., p. 60.

Off the coast of Chili; 2160 fathoms; "Challenger" Station 299.

The type-specimen of this interesting species, 30 mm. in diameter and doubtless young, is still unique.

Kamptosoma indistinctum A. Ag.

Kamptosoma indistinctum A. Agassiz, 1904. Panam. Deep-Sea Ech., Mem. M. C. Z., XXXI, p. 110; Pl. *50.* North of the Society Islands, East of Malden Island, 2600 fathoms; "Challenger" Station 272.

In spite of Mortensen's decision to the contrary, we think this species must be maintained, unless the differences of ambulacral structure referred to above, which distinguish this species from the preceding, can be shown to be unreliable. We beg to call attention to two facts which bear on this point. First: it was only in this species that Mortensen found the large, characteristic tridentate pedicellariæ; they were not found in the type of *asterias.* Second: Mortensen says that secondary ambulacral plate elements are wanting, except "nearest to the peristome a single one may be found." Unfortunately he does not say whether this was observed in the type of *asterias* or in a specimen from "Challenger" Station 272. If in the former, it gives us an additional specific character; if in the latter, we are at a loss to reconcile his statement with the real condition in *indistinctum* (see Panam. Deep-Sea Ech., p. 111, fig. *151* and Plate 50, fig. *3*).

Asthenosoma.

Grube, 1868. 45er Jahres-Bericht d. Schles. Gesell, p. 42.

Type-species, *Asthencsoma varium* Grube, l. c.

After careful consideration it has seemed desirable to limit Asthenosoma, as Mortensen proposed, to the species on which Grube based the genus and its nearest allies. They are characterized by a rather firm test having the actinal side markedly different from the abactinal. The coronal plates of the upper side are very low and wide, each with a horizontal series of 5–20 small primary tubercles, none of which are noticeably larger than the others. The abactinal primary spines are small and numerous, and are encased in loose skin-sheaths. The actinal tube-feet have well-developed sucking-discs. The sphæridia are more or less elongated and occur only on the inner (lower) secondary plate-element. In this limited sense Asthenosoma includes at most only four species, and probably only two. The evidence accumulated by de Loriol, Döderlein, and de Meijere seems to prove that *A. Grubei* A. Ag. is really a synonym of *varium* Grube, as Agassiz himself suggested in 1881 ("Challenger" Echini, p. 84). From the descriptions and figures which have been published we are strongly inclined to consider *A. urens* Sarasins and *A. heteractis* Bedford as also synonyms of *varium*, but as we have no material at hand for comparison, we let them stand for the present as distinct. The following table shows how closely related the four accepted species are:

Actinal primaries more or less distinctly banded (usually greenish banded with purple).
  Ambulacral primary spines, abactinally, much longer than those of interambulacra but not markedly unlike them in color.
    Naked radial areas of abactinal surface, relatively narrow, or wanting; that of median interambulacral field not exceeding .10 of interambulacrum . . . . *varium.*
    Naked radial areas of abactinal surface, conspicuous; that of median interambulacral field exceeding .20 of interambulacrum . . . . *urens.*
  Ambulacral primary spines, abactinally, about equal to those of interambulacra, markedly different from them in appearance, the sheaths being very distinctly and regularly banded with purple . . . . *heteractis.*
Actinal primaries white and unbanded . . . . *Ijimai.*

Asthenosoma varium Grube.

Asthenosoma varium Grube, 1868. 45[er] Jahres-Bericht d. Schles. Gesell., p. 42.

Asthenosoma Grubei A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 200. 1881. "Challenger" Ech., Pls. XV–XVII.

East Indies. Littoral.

There seems to be no sufficient ground, in the present state of our knowledge, for regarding *varium* and *Grubei* as distinct. It is certainly to be doubted whether either of the two succeeding forms is really different from *varium.*

Asthenosoma urens Saras.

Cyanosoma urens Paul and Fritz Sarasin, 1886. Zool. Anz., IX, p. 80.

Asthenosoma urens Paul and Fritz Sarasin, 1888. Ergeb. Nat. Forsch. Ceylon, I, p. 86; Pls. X–XVII.

Ceylon. Littoral.

It seems very doubtful whether this species is distinguishable from *varium,* but further study of fresh material in the East Indies will be necessary before the point can be settled. Attention ought to be called to the astonishing discrepancy between the Sarasins' colored figure (Pl. X) and the photograph given by Döderlein (Semon's Zool. Forsch. Aust., Pl. LX, fig. *3*) of what he tells us is an "Originalexemplar" of *urens* from the Sarasins' collection. It is incredible that this photograph can represent an animal which had ever had the coloration shown in the Sarasins' figure, yet strangely enough Döderlein makes no reference to the color. If *urens* has the coloration shown by the Sarasins it must be very different from *varium ;* while, on the other hand, if Döderlein's figure represents the normal appearance of *urens* it must be very near, if not identical with, Grube's species. The differences described by Döderlein between *varium* and *urens* do not seem to us to be very weighty, and his suggestion that the two forms are varieties of one species seems quite probable, if they are distinguishable at all.

Asthenosoma heteractis Bedford.

Asthenosoma heteractis Bedford, 1900. Proc. Zool. Soc. London, p. 278 ; Pl. XXI, fig. *2.*

Singapore; 5 fathoms.

We do not consider the characters assigned to this species as of very great importance, and we are strongly inclined to think that the original specimens are young examples of *varium.*

Asthenosoma Ijimai Yosh.

Asthenosoma Ijimai Yoshiwara, 1897. Ann. Zool. Japon., I, p. 8; Pl. II, figs. *8–12*.
Asthenosoma Ijimai Mortensen, 1904. Ann. Mag. Nat. Hist. (7) XIV, p. 87; Pls. III; V, figs. *1–3, 10, 12–14*.

Sagami Bay, Japan; 50–55 fathoms.

The arrangement of the tubercles in the interambulacral plates of the abactinal side of the test in this species resembles closely that of *A. varium.* The columns of primary tubercles of the actinal side do not reach beyond the ambitus, and there is nothing of the characteristic arrangement of the extension of the primaries toward the abactinal system so striking in many species of Aræosoma.

Mortensen criticises Yoshiwara's description of the madreporic plate, as he does not consider the madreporic plate divided, but rather that the madreporic pores have spread into adjoining plates. In the specimens before us there seems to be no room to doubt that the madreporic plate is divided, exactly as Yoshiwara described it, "into four separate pieces of unequal size, the largest occupying the normal position." In addition there are a dozen or more very small fragments of the plate, around the genital opening, distal to the main plate. The madreporic pores spread into the ocular plates on each side, but chiefly into the one in the right anterior ambulacrum. The splitting up of the genital plates is now so well known in the Echinothuridæ that the condition of the madreporic plate in this species, while interesting, is far from exceptional. On the other hand, the extension of madreporic pores into anal plates is a very rare phenomenon, never occurring normally so far as we know, so that we cannot assent to Mortensen's interpretation of the condition in *Ijimai.* When he says that the spread of madreporic pores "over the neighboring plates" is a feature "upon the whole not very seldom occurring among Echinids," it must be assumed that he means by "neighboring" plates only genitals and oculars, for the presence of madreporic pores in plates either inside or outside of the genito-ocular ring is most unusual. In *Ijimai*, the plates in question must be either anal plates or parts of the genital, and we feel no doubt that they are the latter.

ARÆOSOMA.

Mortensen, 1903. "Ingolf" Ech., pt. 1, p. 53.
Type-species, *Calveria fenestrata* Wyville Thomson, 1872. Proc. Roy. Soc. London, XX, p. 494.
(Including Calveria and Hapalosoma of Mortensen.)

Actinally this genus is not essentially different from Asthenosoma, but seen from above the difference is quite marked. In Aræosoma none of the abactinal primary spines are encased in loose skin-sheaths. There are at least 25–30, and sometimes several hundred, primary tubercles which are much more conspicuous than the rest and their areolæ are correspondingly large. The coronal plates are also much higher than in Asthenosoma, but the texture of the test varies much in the different species. This is the largest genus of the family, but although the species show some tendency to an arrangement in three or four groups, we have failed to find any satisfactory characters by which such groups may be constantly distinguished. We can hardly believe that the texture of the test, the relative width of ambulacra and interambulacra, or the relative number of ambulacral and interambulacral plates, are any better generic characters, taken by themselves, than the color or the pedicellariæ. And while by using any one of these characters we might arbitrarily establish several "genera," they would intergrade so completely in their other characters, we do not think such subdivisions would be either natural or desirable. Accepting Mortensen's view that *A. Reynoldsii* A. Ag. is a synonym of *fenestratum* Wyv. Thom., and *A. longispinum* Yosh. is identical with *A. gracile* A. Ag., we still recognize 14 species of Aræosoma. They show great diversity in color, texture of the test, distribution of primary spines, relative number of ambulacral and interambulacral plates, relative width of ambulacra and interambulacra, length of spines, and form of pedicellariæ; and it is surprisingly hard to distinguish them from each other, for not only do their characters reveal more or less individual diversity, but they intermingle most perplexingly in the different forms. We have reached the conclusion that color is often a good character in this genus, and it proves to be of considerable service in distinguishing certain species. The form of the valves of the large tridentate pedicellariæ, which can be easily seen with an ordinary lens, is also a useful character, even if we cannot follow Mortensen in making it generic. The width of the ambulacra and the number of ambulacral plates are valuable, within certain limits, but age differences need to be guarded against, and the same is true of the spines

and primary tubercles. Only rarely is the relative size of the actinostome or abactinal system of any importance, but the relative amount of calcification of the coronal plates and the degree to which they are bent adorally are often very useful characters. The species which seem to us probably valid may be distinguished as follows:

Actinal primary tubercles not forming an uninterrupted marginal series at ambulacral edge of each half-interambulacrum, since some interambulacral plates (usually every other one, at least near ambitus) do not have a primary tubercle at extreme outer end.
  Abactinal primary tubercles fewer than 100, nearly or quite as large as those of actinal surface . . . . *thetidis.*
  Abactinal primary tubercles more than 200, much smaller than those of actinal side . . . . *bicolor.*
Actinal primary tubercles forming an uninterrupted marginal series at ambulacral edge of each half-interambulacrum, since each interambulacral plate has a primary tubercle at its extreme outer end.
  Ambulacra very narrow, about .40 of interambulacra; primary spines near ambitus banded with red or reddish-purple . . . . *pellucidum.*
  Ambulacra more than half as wide as interambulacra; primary spines not banded.
    Ambulacra very broad, more than .75 of interambulacra.
      Ambulacra .90 of interambulacra; interambulacral plates much more numerous abactinally than actinally, strongly inclined (near ambitus, curved) towards mouth, those at ambitus with inner end so much more adoral than outer, that the plate is 30 per cent longer than one-half the width of interambulacrum . . . . *eurypatum.*
      Ambulacra .80 of interambulacra; interambulacral plates nearly as numerous actinally as abactinally, more or less oblique, but even at ambitus their length is only about 10 per cent longer than one-half the width of interambulacrum . . . . *leptaleum.*
    Ambulacra moderately broad, .50–.75 of interambulacra.
      Entire test bright red, the color more or less well-preserved in alcoholic and dry specimens; large tridentate pedicellariæ with curved valves having the blade strongly involute except at tip.
        Test bright rose-red; actinostome about .25 h. d.; few actinal interambulacral plates with two or more primaries *hystrix.*
        Test bright vermilion; actinostome less than .20 h. d.; most actinal interambulacral plates with two or more primaries . . . . *pyrochloa.*
      Test never bright red; colors variable, the actinal and abactinal surfaces often different; colors usually more or less bleached or altered in preserved specimens.
        Ambulacral plates rather high and few, interambulacral about four-fifths as many; test reddish-purple above, lighter, often yellowish, beneath . . . . *Belli.*

Ambulacral plates low and numerous, interambulacral only three-fifths — three-fourths as many.
Color uniform dark violet; actinal primary spines (except hoofs) equally dark . . . . *violaeeum.*
Color never uniformly dark violet; actinal primary spines usually lighter than test.
Coronal plates, especially abactinally, with wide interspaces of leathery skin.
Abactinal interambulacral plates strongly curved or bent adorally so that their expanded inner ends are much nearer mouth than the outer ends, in large specimens as much as 15 mm. nearer . . . . *coriaceum.*
Abactinal interambulacral plates nearly or quite straight, though they are not necessarily horizontal . . . . *tessellatum.*
Coronal plates with small interspaces or none.
Number of ambulacral plates abactinally little or not at all exceeding actinal number *fenestratum.*
Ambulacral plates abactinally 50–60 per cent more numerous than actinally.
Test thin; valves of large tridentate pedicellariæ curved, with blades strongly involute except where they meet at tip *gracile.*
Test rather stout; valves of large tridentate pedicellariæ straight or nearly so, the blades not involute but in contact for most of their length . . . *Owstoni.*

Aræosoma thetidis A. Ag. and Cl.

Asthenosoma thetidis H. L. Clark, 1909. Bull. M. C. Z., LII, p. 134.
Off Botany Bay, New South Wales; 80 fathoms.

Plates 66, figs. *6–17;* 68–70.

Although at first sight this species appears to be closely related to *A. Owstoni* Mort., careful examination reveals some very decided differences, particularly on the actinal surface. The largest specimen before us measures 180 mm. in diameter; the interambulacra are 63 mm. broad at the ambitus, while the ambulacra are 46 mm. across in the same region. The abactinal system is 32 mm. in diameter, while the actinostome is 41 mm. across. There are 45 coronal plates in each half of an interambulacrum, of which 18 are below the ambitus. The ambulacral plates number 70 from the peristome to the ocular plate; of these 28 are on the actinal side; there are 12–14 additional pairs of poriferous plates in each radius of the actinostome. The primordial interambulacral plate at the peristome is very evident (Pls. 69; 70, fig. *2*) and bears several small primary tubercles.

The other actinal coronal plates each carry one or two primary tubercles; these vary greatly in their position on the plate, but as a rule every other plate has one such tubercle near its outer end and a second near the inner end; the alternating plates usually have a single large tubercle at the middle, but occasionally there are two tubercles present. Sometimes a plate occurs with no primary tubercles. It will be seen, therefore (Pl. 69), that there is a tendency to form three well-spaced longitudinal series in each half of the interambulacrum. On the abactinal surface most of the coronal plates carry no primary tubercles, but six or eight plates in each column are made conspicuous (Pl. 68) by the single large tubercle which each bears. The inner, imbricating ends of the coronal plates are abactinally quite bare and perfectly smooth (Pl. 68), but there is no uncalcified membrane between the plates, except for a very small area at the lower margin of about a dozen plates, beginning with the fifth or sixth from the genital plate. Actinally the coronal plates are well covered, clear to the median line, with secondaries and miliaries, but abactinally the margins of each plate are, on all sides, more or less bare.

Each half-column of an ambulacrum actinally (Pl. 69) is made up of very wide, rather large primary plates, each accompanied by two small secondary plate-elements. The latter are very little larger than the peripodium which each bears. Although the tubercles are arranged in two series, on each side, their distribution is quite irregular. It is rather more common to find two tubercles on a single plate, one at each end, with the adjoining plates above and below without tubercles, than to find them alternating, as might be expected, plates with a tubercle at the inner end succeeding and being followed by plates with an outer tubercle. Abactinally (Pl. 68) only five or six plates in each column bear large tubercles, and these are irregularly scattered. The remaining surface of the ambulacral plates is fully covered actinally with secondaries and miliaries, but abactinally the margins of each plate, especially the outer ends, are quite smooth and bare. The three series of pore-pairs run rather close together the full length of the ambulacrum; even just above the ambitus (Pl. 70, fig. *4*) the outer series (in the primary plates) is not very widely separated from those in the secondary plates.

The abactinal system (Pl. 70, fig. *1*) is small and well defined. The genital and ocular plates are not in contact with one another. The genitals are long, triangular, separating the two upper pairs of plates of each interambulacrum; the pores are large, occupying the greater part of the distal

half of the plate. The ocular plates are somewhat pentagonal, with very small pores. The anal system is large, 18 mm. across, and is covered by several concentric circles of small plates, the inner ones the smallest; many of the outer ones carry one or more secondary spines.

The smallest specimen of *thetidis* which we have is 72 mm. across, with the actinal system 18 mm., the abactinal system 11 mm., and the anal system 8 mm. in diameter. The interambulacra are 26 mm. wide at the ambitus and have 32 plates in each half-column, while the ambulacra are 20 mm. wide and are made up of 43 pairs of plates. The primary tubercles of the abactinal side are about as numerous as in large specimens and therefore appear much more numerous relatively. Actinally they are fewer and tend to form a regular marginal row along the outer border of each interambulacrum, a much less regular series at the inner ends of the same plates, and two very irregular series in the middle of each ambulacrum.

The spines of this species offer no peculiarities and the pedicellariæ are very much like those of *Owstoni* and *bicolor*. We have not found any "dactylous" ones, however, although careful examination has been made of several specimens. The tridentate pedicellariæ are exceedingly abundant, particularly just below the ambitus, while the triphyllous are less common.

The *tridentate* pedicellariæ (Pl. 66, figs. *15*, *17*) are extraordinarily diversified in size and form, though on the same general plan. The heads are thick and blunt, and the stalks are about twice as long as the head or longer. The valves (Pl. 66, figs. *6–12*) range in length from one-fifth of a millimeter to over two millimeters; they are in contact for nearly their entire length, except in rare cases, where only the terminal halves touch. In small pedicellariæ, the valves have a nearly straight or somewhat convex, smooth margin, but in the larger ones it is more and more sinuate, until in the largest it is very coarsely toothed. In all large pedicellariæ the blade is filled with a coarse mesh-work which may rise up into irregular serrate ridges (Pl. 66, figs. *11* and *12*); in large valves the tip may be very strongly hooked.

The *triphyllous* pedicellariæ (Pl. 66, fig. *16*) are not very numerous and have rather elongated heads on slender stalks; the valves (fig. *17*) are narrow, with a very long, perforated cover-plate, and rounded at the tip. The *calcareous spicules* (Pl. 66, fig. *13*) in the tube-feet are small, irregular, but essentially triradiate, bodies, sometimes appearing as small perforated plates.

Aræosoma bicolor A. Ag. and Cl.

Asthenosoma bicolor A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 118.

Plates 64, figs. *1–8*; 71; 72.

This species, of which only a single specimen was collected, is nearly related to *Owstoni*, but differs in color and in certain features of the test. The coronal plates are low and very numerous, 44 in the interambulacra and 75 in the ambulacra (Pls. 71, 72, figs. *3*, *4*); in *Owstoni* of the same size (125 mm.) the numbers are 38 and 60 respectively. The test is more flexible abactinally than in *Owstoni*, and the bare median ambulacral and interambulacral areas are more marked (Pl. 71, figs. *1*, *2*). The test and spines are dull yellowish actinally, while on the abactinal surface the interambulacra are chiefly yellow and the ambulacra are dull violet. These colors are not sharply defined, but contrast with each other nevertheless. On the actinal side the primary ambulacral tubercles form two median longitudinal series (Pl. 71, fig. *2*). At the ambitus there are two additional series of primaries somewhat smaller which extend irregularly along the ambulacrum for about two-thirds the distance from the ambitus to the apex (Pl. 71, fig. *1*). The actinal primary interambulacral tubercles are arranged in six very irregular rows; in the outer rows, adjoining the ambulacral area, they are closely packed (Pl. 71, fig. *2*) two-thirds of the distance from peristome to ambitus. On the abactinal surface the primary interambulacral tubercles extend in irregular open rows almost to the apical system (Pl. 71, fig. *1*). The rest of the plate is closely covered with miliaries (Pl. 72, fig. *4*). The primordial actinal interambulacral plate is large and prominent (Pl. 72, fig. *1*). The imbricating actinal plates, in prolongation of the ambulacral series, cover the whole buccal membrane except at the actinal margin of the interambulacra, where there are a few minute plates (Pl. 72, fig. *1*). The actinal plates are covered with minute secondaries and miliaries arranged in horizontal rows.

The genital plates in *bicolor* are not so elongated as in *Owstoni*, for they separate only the first pair of interambulacral plates and touch the second (Pl. 72, fig. *2*), while in *Owstoni* they separate the first two pairs and touch, sometimes nearly separating, the third. In *bicolor* four of the genital plates are remarkable in that the outer part of the plate (i. e. the part distal to the pore) is separated by a regular suture from the remainder of the genital and

thus is a perfectly distinct plate (Pl. 72, fig. *2*). The madreporic genital is divided into three parts. The anal system is covered with two outer rows of small irregularly shaped polygonal plates, each carrying a small miliary or secondary; close to the anus the membrane is covered by minute elliptical plates.

The pedicellariæ of this species resemble closely those of *Owstoni*, but show some interesting differences.

The *dactylous* pedicellariæ (Pl. 64, fig. *1*) are very scarce and seem to be confined to the actinal side near the ambitus. The stalk is much longer than the head. The three valves are about 1.4 mm. long and completely concealed in the glandular tissue which surrounds them; when cleaned from this organic matter they are found to be very asymmetrical (Pl. 64, fig. *4*); the blade is greatly compressed for most of its length, but is expanded, with infolded margins, at the tip, and is more or less abruptly bent below this expanded tip.

The *tridentate* pedicellariæ (Pl. 64, fig. *2*) are very abundant and vary greatly in size and somewhat in form, though the connecting links are plentiful. The smallest have the valves (Pl. 64, fig. 7) about .45 mm. long, very blunt, with nearly parallel, straight sides; the apophysis continues to some extent into the blade. In the largest, the valves (Pl. 64, figs. *5*, *6*) are two and a half millimeters long, narrow, and more or less closely in contact throughout; the blade has a very sinuate margin, and on the convex curves the margin is somewhat infolded and rough, with minute teeth (see fig. *6*); the blade is filled with a calcareous mesh-work and the apophysis is prolonged as a prominent, serrate ridge. Between these two extremes all sorts and sizes of tridentate pedicellariæ may be found.

The *triphyllous* pedicellariæ (Pl. 64, fig. *3*) have very long and slender stalks and rather long necks; the valves (fig. *8*) are about half a millimeter long, and like those of *thetidis* and *Owstoni* have a very extensive, more or less perforated, cover-plate. The sphæridia and calcareous spicules are not noteworthy.

This species is based on a single specimen, 125 mm. in diameter, taken by the "Albatross" at the following station:

Station 4939. Kagoshima Gulf, Japan; 31° 18′ 30″ N., 130° 42′ E. 85 fathoms. Character and temperature of bottom not recorded.

Aræosoma pellucidum A. Ag. and Cl.

Asthenosoma pellucidum A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 200. 1881. "Challenger" Ech., Pls. XVIII, figs. *1–6*; XIX, figs. *1–6*; etc.
Hapalosoma pellucidum Mortensen, 1903. "Ingolf" Ech., pt. I, p. 56.
East Indies; 100–129 fathoms.

The small size, pretty colors, and very narrow ambulacra combine to make this a very easily recognized species. The "Albatross" specimens which are less than 50 mm. in diameter, and intermediate in size between those figured on the "Challenger" Ech. Pl. XIX, figs. *1–6*, were taken at the following station:

Station 4934. Off Kagoshima Gulf; 30° 58′ 30″ N., 130° 32′ E. 103–152 fathoms. Rocky.

Three specimens.

Aræosoma eurypatum A. Ag. and Cl.

Plates 66, figs. *18–19*; 73–75.

As far as can be judged from the single specimen of this species, the test must have been very flexible, the outline was lobed, the median ambulacral and interambulacral lines bulging out beyond the vertical furrow formed at the junction of the ambulacral and interambulacral zones (Pl. 73). The curve of the test at the ambitus is high, projecting well beyond the concave abactinal surface of the test at the centre of which rises the abactinal system (Pl. 73, fig. *1*). This is well seen in the profile view of the test (Pl. 73, fig. *2*) as well as in the figure taken from the actinal side (Pl. 74), which also shows the ambitus swelling well above the concave actinal surface in the centre of which rises the highly arched, slightly conical actinal system. The test of the specimen figured is, as far as it can be measured in its dry and somewhat folded state, 140 mm. in diameter; the actinal system is 35 mm. across, while the abactinal measures 20–25 mm. from the distal tip of a genital plate to the distal edge of the opposite ocular plate (Pl. 75, fig. *2*). From the ambitus to the abactinal system in the ambulacral zone there are 42 plates and in the interambulacral zone 32. On the actinal side in the interambulacral column there are 19 plates and in the ambulacral 31. The test of this species is remarkable for the great uniformity in the size of the coronal plates. Those of the actinal side are but little larger than those of the abactinal side (compare Pls. 73 and 74). The interambulacral plates

of the abactinal side are curved downward toward the ambitus from the outer edge of the interambulacral zone to the median line (Pl. 73, fig. *1*) all the way from the abactinal system to the ambitus (Pl. 75, fig. *2*). The same is the case with the ambulacral plates to a limited extent, only the plates about one-third of the way from the ambitus towards the abactinal system being curved towards the median ambulacral line (Pl. 73, fig. *1*), those nearer the abactinal system being only slightly curved or horizontal (Pl. 75, fig. *2*).

At the ambitus the ambulacral and interambulacral areas are of nearly the same width (Pls. 73, 74). On the abactinal side the interambulacral areas are bordered along the ambulacra by a more or less regular vertical series of small primary tubercles flanked near the ambitus by a shorter row of similar tubercles extending on five or six interambulacral plates. The rest of the interambulacral plates are for the most part covered with distinct small secondaries and miliaries, but along the median interambulacral line are found two rows of small primaries extending from the actinal side to the abactinal side of the ambitus. These rows are well seen in the profile view of the test (Pl. 73, fig. *2*). On the abactinal surface, in the median ambulacral area, occur two or three irregular vertical series of small distant primaries and secondaries extending from the ambitus to the abactinal system. The poriferous zones on the abactinal surface occupy two-thirds of the ambulacral area; the two vertical inner rows of pairs of pores are well separated from the single outer line (Pl. 75, fig. *4*).

On the actinal side the poriferous zones approach the outer edge of the ambulacra and at the actinostome are closely packed (Pl. 75, figs. *1*, *3*). On the actinal side of the test (Pl. 74) the interambulacral plates are of uniform height, sharply inclined towards the median line; only the nine or ten plates nearest the actinostome are separated by uncalcified membrane. The vertical series of interambulacral primaries next the ambulacra are regular and prominent (Pl. 74), while the less marked rows of similar tubercles on each side of the median interambulacral line are not very noticeable. The actinal system is about 35 mm. in diameter and has prominent gill cuts. There are twelve to fourteen rows of narrow imbricating plates between the teeth and the ambulacral coronal plates (Pl. 75, fig. *1*), which carry secondaries arranged in horizontal rows.

The abactinal system (Pl. 75, fig. *2*) is from 20 to 25 mm. in diameter. The genital plates are pointed and much elongated with the genital openings placed in the proximal part of the genital membrane, which carries

along its edges small irregularly shaped polygonal plates. The proximal part of the genital plate is divided into two large plates each of which carries a small secondary. The ocular plates are polygonal, separating the genitals, and each carries one or two secondaries.

The anal system is covered with irregular polygonal plates varying greatly in size (Pl. 75, fig. *2*), with a few small elliptical plates round the anal opening, arranged in two irregular rows.

As this species is allied to *A. coriaceum*, it is interesting to compare the details of the abactinal system given on Plate 52 of the Panamic Deep Sea Echini (Mem. M. C. Z., XXXI) with those of *A. eurypatum* on Plate 75 of this Memoir.

The test is scraped so nearly bare, only a very few broken, secondary spines, a few triphyllous pedicellariæ and some scattered sphæridia are left in a couple of abactinal folds of the test. The sphæridia (Pl. 66, fig. *18*) are remarkable for their greatly elongated form; they are more spine-like than in any other known Echinothurid. The triphyllous pedicellariæ are, as usual, on long, slender stalks; the valves (Pl. 66, fig. *19*) are noticeably slender but expand rather abruptly at the tip, where they are very flat; they are about half a millimeter long and have a well-developed cover-plate with an irregular margin.

This remarkable specimen was taken in 1888 by the "Albatross" on her way from New York to San Francisco, at the following station:

Station 2819. Near Galapagos Islands; 6′ S., 90° 6′ W. Bott. temp. 39.9°. 671 fathoms. Wh. s.

Aræosoma leptaleum A. Ag. and Cl.

Plates 76 and 77.

This species belongs to the *fenestratum* group of Aræosoma, and may be considered the Pacific representative of that Atlantic species. A single specimen was collected by the "Albatross" in 1904 off Mariato Point, while looking up for further investigation the green-sand patch discovered by her in the Panamic region during the cruise of 1891.

The diameter of this specimen is 125 mm.; the greatest diameter of the abactinal system 21 mm.; of the actinal system, 30 mm. There are 19 plates in each half of an interambulacrum from the actinal system to the

ambitus and 27 in the ambulacral column. Between the abactinal system and the ambitus there are 24 plates in each half of an interambulacrum and 38 in an ambulacrum. At the ambitus the interambulacral area has a width of 42 mm., the ambulacral, 32. The greatest diameter of the abactinal system is 21 mm., that of the actinal system 30 mm. The primary spines both on the actinal and abactinal surfaces are sharp and slender, from 12 to 22 mm. in length (Pl. 76). The longer spines of the actinal side are slightly expanded at the tip (Pl. 76, fig. *2*), and terminate in a small white "hoof" which is remarkable for being thickest at base and nearly pointed at tip. Between the actinal interambulacral plates there is even more uncalcified membrane than in *A. fenestratum*. On the abactinal side the calcification of the plates increases gradually from below the ambitus to the abactinal system (Pl. 76, fig. *1*). Both the ambulacral and interambulacral plates are higher in *fenestratum* than in *leptaleum*.

On the actinal side the vertical row of interambulacral primaries bordering the ambulacrum is very marked, and extends just over the ambitus to the abactinal surface, close to the ambulacral plates. On the abactinal surface two irregular series of smaller primaries extend on each half of the interambulacrum, two-thirds of the way to the abactinal system (Pl. 76, fig. *1*). The two median rows of ambulacral primary tubercles are distant and irregular (Pl. 77, fig. *3*), but extend from the actinostome (Pl. 77, fig. *1*) over the ambitus (Pl. 77, fig. *4*) nearly to the abactinal system (Pl. 76, fig. *1*). The two inner series of pairs of pores are well separated from the outer row for nearly the whole length of the ambulacrum (Pl. 77, fig. *4*), approaching closely only near the actinostome (Pl. 77, fig. *3*).

There are from ten to twelve rows of rather high imbricating poriferous plates extending from the teeth to the coronal, ambulacral plates (Pl. 77, fig. *1*). They each carry a horizontal row of small secondaries and miliaries. The small area between the ambulacral plates at the proximal margin of the primary interambulacral plate is covered with a few minute elliptical plates. The actinal plates near the teeth all abut on each other as regularly as the coronal plates of the typical echinoid test; it is only the plates near the coronal plates which are imbricating. The median suture of the interambulacral area extends almost unbroken from the actinal edge of the test to the teeth, and the adjoining ambulacral areas

are separated only near the corona by the small irregular wedge-shaped interambulacral plates. Such an arrangement is suggestive of Bothriocidaris, where the interambulacral area is reduced to a minimum.

The abactinal system is comparatively small (Pl. 77, fig. *2*). The genital plates are pointed triangular with rounded angles, while the genital membranes are elongated and more or less rectangular. The genital plate is made up of two parts, a small outer piece distal to the membrane and a broadly horse-shoe-shaped plate proximally, which carries from one to three small secondaries or miliaries. The madreporic body is transverse elongate with slightly concave sides. The anal system is covered with two outer rows of larger polygonal plates, each carrying one or two secondaries or miliaries and two or three interior series of small elliptical and polygonal plates adjacent to the anus.

The pedicellariæ of this species are remarkably indistinctive, and it has not seemed necessary to figure them. No dactylous pedicellariæ were found. The *tridentate* pedicellariæ are not very abundant and show comparatively little diversity of size. Most of them have the heads about a millimeter long and the stalk three or four times that length. The shape of the head and valves is much like what we find in *thetidis* (see Pl. 66, fig. *17*), but some pedicellariæ are much more like those of Sperosoma (see Pl. 64, fig. *9*). Occasionally one is met with which approaches fig. *12*, Pl. 67, and the valves are often broadened distally and narrowed near the base, like fig. *13*, Pl. 67.

The *triphyllous* pedicellariæ are more common, though hardly abundant. The necks and stalks are very long and slender; the valves are very much like that shown in fig. *19*, Pl. 66, but are not quite so flattened or abruptly widened at the tip.

The *sphæridia* are very long and club-shaped, reminding one very much of those of the previous species (*eurypatum*).

The single specimen of this interesting species was taken by the "Albatross" at the following station:

Station 4621. Off Mariato Point, Panama; 6° 36′ N., 81° 44′ W. 581 fathoms; modern green-sand; temperature of bottom not recorded, but adjoining this station, 40.2° was recorded in 555 fathoms, in 1891.

Aræosoma hystrix A. Ag. and Cl.

Calveria hystrix Carpenter and Jeffreys, 1871. Proc. Roy. Soc. London, XIX, p. 154.
Calveria hystrix Wyv. Thomson, 1872. Proc. Roy. Soc. London, XX, p. 494.
(Not *Calveria hystrix* Carpenter, Jeffreys and Thomson, 1870, Proc. Roy. Soc. London, XVIII, p. 445.)
Asthenosoma hystrix A. Agassiz, 1872. Rev. Ech. Pt. I, p. 93.
North Atlantic; 100–1000 fathoms.

In confirming Agassiz's rejection of Calveria (Pan. Deep-Sea Ech., p. 84), Bather has pointed out (Ann. Mag. Nat. Hist. (7) XVII, p. 249) that the specific name (*hystrix*) having been rejected as a homonym, it should not be used for this species. This may be correct nomenclature, but we cannot see what is gained by any change from the universally used specific name.

Aræosoma pyrochloa A. Ag. and Cl.

Asthenosoma pyrochloa A. Agassiz and Clark, 1907. Bull. M. C. Z., LI. p. 118.

Plates 66, figs. *1–4;* 78–80.

Although this species bears a close resemblance to the preceding, the differences pointed out on p. 175 seem to be constant, and warrant the recognition of this form as the North Pacific representative of *A. hystrix.* The small size of the actinostome is particularly worthy of note. The diameter of the specimen figured on Plates 78 and 79 is 196 mm. From the ambitus to the abactinal system there are in each column 35 interambulacral plates, each carrying from one to four primary tubercles arranged in four or five irregular vertical rows. On the actinal side of the test there are 25 plates in each half-interambulacrum, and each plate carries two to four primary tubercles, one of which is always at the extreme ambulacral end of the plate. A very complete marginal series is thus formed, but the series near the median line is much less regular. The rest of the interambulacral plates are covered with numerous secondaries and miliaries. The plates increase in height somewhat as they pass from the ambitus towards the abactinal system and actinostome. On the abactinal side of the test (Pl. 78) there are in each column 48 ambulacral plates, increasing very gradually in height from the ambitus to the abactinal system. Each plate carries one or two primary tubercles, which form two very irregular vertical rows on each half-ambulacrum. Excepting the extreme outer end, the ambulacral plates are covered with a series of large miliaries. Towards the ambitus, on the abactinal side of the test, the poriferous zone is equal in width to half that

of the ambulacral plates. At the ambitus the width of the ambulacral area is 50 mm., and that of the interambulacral 73 mm. There is a narrow bare space running between the ambulacral and the interambulacral areas, and a somewhat wider bare space on the median interambulacral line. On the actinal side there are 34 plates in each half-ambulacrum. These plates carry two principal vertical rows of primary tubercles (Pl. 79); one row of small tubercles extends from the actinostome above the ambitus in the space separating the single series of pores from the double column, and one row of large tubercles runs along the median ambulacral line. The latter is flanked with an irregular row of smaller primaries extending about half way from the ambitus to the actinal system. The rest of the ambulacral plates carry small secondaries and miliaries irregularly arranged, as on the interambulacral plates.

The uncalcified membrane between the interambulacral plates has its greatest width about half way between the ambitus and the actinal system. On the abactinal side of the test (Pl. 79) the bare space separating the coronal plates is reduced to a narrow line (Pl. 80, fig. *4*).

On the actinal side of the test many of the larger primary spines are somewhat flaring at the extremity; the others are straight and sharp, as are the miliary and secondary spines. On the abactinal side of the test the primary spines are sharp, slender, and straight, very slightly tapering. The miliary and secondary spines are slender and fine; those of the abactinal part of the test are longer than the others, especially in the interambulacral area.

The greatest diameter of the abactinal system is 26 mm. (Pl. 80, fig. *2*). The genital plates are comparatively small, very pointed, with a broad plate adjoining the anal system and smaller plates adjoining the genital membranes. The larger plates carry from five to seven secondaries, with a few miliaries irregularly arranged; the other plates carry large or small miliaries according to their size.

The oculars are large, irregularly heptagonal (Pl. 80, fig. *2*), carrying, next to the anal system, from seven to ten medium-sized secondaries with a few miliaries. The ocular pore is very small. The anal system is covered by three or four unevenly concentric rows of irregularly shaped polygonal plates, carrying small secondaries like those of the genital and ocular plates, and occasionally a few small miliaries, with an inner belt of very small elliptical plates round the anal opening.

The madreporic body is divided into two plates, the larger being rectangularly elongated transversely, forming the proximal base of the genital plate; the smaller is pentagonal and adjoins the odd anterior ocular plate.

The actinal system measures 32 mm. in greatest diameter. It is covered with twelve or thirteen rows of imbricating concentric ambulacral plates, each carrying a horizontal row of small secondaries (Pl. 80, fig. *1*). The plates do not extend quite to the teeth, and diminish rapidly in size from the base of the corona where they overlap sideways and vertically. A wide, bare, triangular space is thus left between each set of ambulacral plates (Pl. 80, fig. *1*) next the teeth, much as in *A. thetidis*, but not quite as marked as in that species (Pl. 70, fig. *2*).

The pedicellariæ of *pyrochloa* are so nearly like those of *hystrix* that no extended description is necessary. The *large tridentate* (Pl. 66, fig. *1*) have the valves .80–1.75 mm. long, while in the *small tridentate* (fig. *2*) they are only .70–.85 mm. in length. The *triphyllous* pedicellariæ (Pl. 66, fig. *3*) are very small, on very slender stalks; the valves measure only .30–.40 mm. in length. The *sphæridia* are somewhat club-shaped, .50–.60 mm. long. The *calcareous spicules* in the tube-feet are very numerous perforated plates of irregular form and size; some are nearly half a millimeter in diameter, and have about a hundred perforations.

This species was taken by the "Albatross" at the following stations, the specimens ranging from 100 to 195 mm. in diameter:

Station 4919. Off Kagoshima Gulf, Japan; 30° 34′ N., 129° 19′ 30″ E. Bott. temp. 41.8°. 440 fathoms. Glob. oz.

Station 5086. Off Joka Sima Light, Japan; 35° 8′ 15″ N., 139° 20′ E. Bott. temp. 43.7°. 292 fathoms. Gn. m., crs. bk. s.

Three specimens.

Aræosoma Belli Mortens.

Asthenosoma hystrix A. Agassiz, 1874. "Hassler" Ech., Mem. M. C. Z., IV, p. 3; Pl. II, figs. *1*, *2*. 1880. Bull. M. C. Z., VIII, p. 74.
Aræosoma Belli Mortensen, 1903. "Ingolf" Ech., I, p. 55.
Caribbean Sea; 103–140 fathoms.

Plate 66, fig. *5*.

Although Mortensen's species is based on the characters shown by the pedicellariæ, we find that the peculiarities of the test, pointed out in 1874,

justify the recognition of this small West Indian species. The largest specimen before us is only 105 mm. in diameter.

This species is readily distinguished from *A. hystrix* by the greater height of both the ambulacral and interambulacral plates. In a specimen of *A. Belli* 72 mm. in diameter there are 22 interambulacral and 27 ambulacral plates in each column, from the ambitus to the abactinal system. On the actinal side, 16 interambulacral and 17 ambulacral plates in a column lie between the ambitus and the actinal system.

In a specimen of the same species 105 mm. in diameter there are 27 interambulacral and 40 ambulacral plates between the ambitus to the abactinal system. On this actinal side there are, from the ambitus to the actinal system, 18 interambulacral and 18 ambulacral plates.

In a specimen of *A. hystrix* 130 mm. in diameter we find on the abactinal side 27 interambulacral and 38 ambulacral plates between the abactinal system and the ambitus, and on the actinal side between the actinal system and the ambitus there are 22 interambulacral and 33 ambulacral plates.

In *A. Belli* there are two principal columns of interambulacral primaries on the actinal side, one of which includes a primary on each plate adjoining the ambulacral system; the other is nearer the median line, and includes only one on every other plate. These columns extend but little beyond the ambitus ("Hassler" Ech., Pl. II, figs. *1*, *2*); a secondary column of distant and irregularly placed primaries extends from the ambitus to the abactinal system. The ambulacral and interambulacral plates each carry one irregular row of small secondaries and miliaries at the centre of the plate.

In *A. hystrix* there are on the interambulacral plates six or seven vertical rows of primaries and secondaries, four of which are more prominent and regular than the others. In the median ambulacral area there are two series of primary tubercles. The rest of the plates, in both areas, are thickly covered with miliaries and a few very small secondaries.

The arrangement of the primaries and secondaries is much the same on the abactinal side, with the exception that the primary tubercles are smaller.

There are, both in *A. Belli* and *A. hystrix*, on the actinal side, spines with hoofs and many with a flaring extremity.

Aræosoma violaceum Mortens.

Aræosoma violaceum Mortensen, 1903. "Ingolf" Ech., I, p. 176.
West of Ireland; 199 fathoms.

We know nothing further of this species than what is given in the original brief description.

Aræosoma coriaceum Mortens.

Asthenosoma coriaceum A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 201. 1881. "Challenger" Ech., Pl. XVIIa, figs. *5–7*. 1904. Pan. Deep Sea Ech., p. 115, Pl. 52.
Aræosoma coriaceum Mortensen, 1903. "Ingolf" Ech., I, p. 53.
Vicinity of Tonga and Fiji Islands; 240–310 fathoms.

The large size, dark brown color, and very leathery test are noticeable features of this species.

Aræosoma tessellatum Mortens.

Asthenosoma tessellatum A. Agassiz, 1879. Proc. Am. Acad., XIV, p. 201. 1881. "Challenger" Ech., Pls. XIXa, fig. *1;* XIXb. (Not *A. tessellatum* A. Ag. and Cl., 1907. Bull. M. C. Z., LI, p. 117.)
Aræosoma tessellatum Mortensen, 1903. "Ingolf" Ech., I, p. 54.
Philippine Islands; 100–115 fathoms. Kei Islands; 168 fathoms.

We are unable to add anything further to the facts known about this species.

Aræosoma fenestratum Mortens.

Calveria fenestrata Wyville Thomson, 1872. Proc. Roy. Soc. London, XX, p. 494. 1874. Phil. Trans. Roy. Soc. London, 164, pt. 2, Pls. LXIII, figs. *9*, *10;* LXVI, LXVII.
Asthenosoma fenestratum A. Agassiz, 1881. "Challenger" Ech., p. 210.
Aræosoma fenestratum Mortensen, 1903. "Ingolf" Ech., I, p. 52.
Asthenosoma Reynoldsii A. Agassiz, 1880. Bull. M. C. Z., VIII, p. 75.
Asthenosoma hystrix A. Agassiz, 1883. "Blake" Ech., Pls. XIII, XIV.
North Atlantic Ocean; 81–373 fathoms.

Pl. 66, fig. *20*.

While we do not feel sure that the Caribbean species (*Reynoldsii*) is identical with Wyville Thomson's *fenestratum*, as we have had no European specimens for comparison, it seems to be true, as Mortensen has pointed out, that both are distinct from *hystrix*. It is worthy of note that in the Caribbean specimens the dactylous pedicellariæ, which may be entirely wanting in otherwise normal specimens, not rarely have five valves (Pl. 66, fig. *20*). The very large tridentate pedicellariæ are sometimes wanting.

Aræosoma gracile A. Ag. and Cl.

Asthenosoma gracile A. Agassiz, 1881. "Challenger" Ech., p. 89; Pl. XVIIa, figs. *1–4*.
Asthenosoma longispinum Yoshiwara, 1897. Ann. Zool. Japon., I, p. 5.
Calveria gracilis Mortensen, 1903. "Ingolf" Ech., I, p. 51.
Asthenosoma tessellatum A. Ag. and Cl., 1907. Bull. M. C. Z., LI, p. 117. (Not *A. tessellatum* A. Ag. "Challenger" Ech., p. 88.)

Off Japan and the Philippines; 50–255 fathoms.

Plates 81, figs. *3, 4*; 82, figs. *5–8*.

On drying the specimen and making a more careful examination of it, we find that we were mistaken in referring to *A. tessellatum* an Echinothurid taken by the "Albatross" in 1906. The specimen is badly damaged, and the uniform dark brown color like that of *tessellatum* misled us. In spite of the peculiar color, it seems best to us now to refer the specimen to *A. gracile*, the structure of the test and the pedicellariæ agreeing well with that species. But there can be little doubt that *gracile* and *pyrochloa* are very near each other and both are very near *hystrix*, and the differences of color are as important as any that have been pointed out. But if we make color the criterion, the specimen before us cannot belong to any of the three species mentioned.

We refer to *gracile* with some hesitation, the small specimen from Station 3750, shown on Plate 81 (figs. *3–4*). The arrangement of the actinal tube-feet shows clearly that it is an Aræosoma, while comparison with young specimens of *Owstoni*, the commonest Japanese form of that genus, shows it cannot belong to that species. The coronal plates are much more numerous than in *Owstoni* at the same age, and the tuberculation of the test is different, the abactinal interambulacral plates being quite bare (Pl. 81, fig. *4*). As the large pedicellariæ are like those of *gracile* and *pyrochloa*, we believe it belongs to one of those species (though the color is quite bleached), and the depth at which it was taken certainly indicates *gracile*.

The specimens, which are 30 and 140 mm. in diameter respectively, were taken by the "Albatross" at the following stations:

Station 3750. Off Suno Saki, Honshu Island, Japan. 83–140 fathoms.[1] Gy. s., brk., sh., p.

Station 4943. Kagoshima Gulf, Japan; 31° 24′ 35″ N., 130° 38′ 40″ E. 119 fathoms. Character and temperature of bottom not recorded.

[1] The label with the specimen gives the depth as 83–89 fathoms.

Aræosoma Owstoni Mortens.

Aræosoma Owstoni Mortensen, 1904. Ann. Mag. Nat. Hist. (7) XIV, p. 82; Pls. II and V, figs. *4–9, 11, 18–20.*

Asthenosoma Owstoni A. Agassiz and Clark, 1907. Bull. M. C. Z. LI, p. 117.

Sagami Bay, Japan; 50 fathoms.

Plates 81, figs. *1, 2, 5, 6;* 82, figs. *1–4.*

The specimens before us show considerable diversity of color, but it is difficult to say how much of this is due to preservation. The small individuals are very pale, almost white. Some medium-sized specimens are decidedly reddish; one is nearly brick red. The larger specimens are dull pale purplish. In most of the specimens the actinal spines are decidedly pinkish, while those of the abactinal side are greenish or not colored. The pedicellariæ agree with Mortensen's description and figures. Young specimens of *A. Owstoni* measuring 53 mm. and 21 mm. in diameter (Pls. 81, figs. *1, 2, 5, 6;* 82, figs. *1–4*) are characterized by the proportionally wider ambulacral area as compared to the interambulacral one. In the specimen measuring 53 mm. in diameter (Pl. 81, fig. *2*) the actinal primary interambulacral spines already carry a hoof. In the smaller specimen all the actinal primary spines are broken or missing. The hoofs are very numerous and very large on the primary actinal interambulacral spines of large specimens (150 mm. in diameter).

In the younger specimen (21 mm.) the two principal vertical rows of interambulacral primaries are largest near the apical system (Pl. 81, fig. *5*), but in the older one (Pl. 81, fig. *1*) they already have all the characters of the larger and full-grown specimens, both on the actinal and abactinal side of the test. In the specimen of 52 mm. the primary abactinal interambulacral spines are proportionally more slender and longer than in larger specimens (150 mm. in diameter) in which they are relatively stout.

The actinal system of the 52 mm. specimen (Pl. 82, fig. *1*) is covered with four and five horizontal rows of ambulacral plates, and close to the interambulacra there are a few minute elliptical plates. The ambulacral plates carry a small secondary at the extremity of each plate and occasionally a small miliary. At this stage (Pl. 81, fig. *1*) the genitals and oculars are of nearly the same size, the genitals separating the oculars (Pl. 82, fig. *2*). The oculars, as in the young of many other species of Aræosoma, extend outward between the two upper plates of the adjoining interambulacral areas. The

genitals and oculars each carry a small secondary, with one or two miliaries in the central part of the proximal margin of the plate. The anal system is covered with three or four irregular concentric rows of polygonal plates, a few of the larger of which each carry a small secondary.

In the small specimen, measuring 21 mm. in diameter (Pl. 81, figs. *4, 5*), there are from the ambitus to the abactinal system 9 interambulacral and 15 ambulacral plates, in each column, while between the ambitus and the actinal system there are 7 interambulacral and 12 ambulacral plates. In the specimen measuring 52 mm. in diameter (Pl. 81, figs. *1, 2*) there are 14 interambulacral and 23 ambulacral plates, from the ambitus to the abactinal system. On the actinal side there are 11 interambulacral and 14 ambulacral plates from the ambitus to the actinal system. In a large specimen measuring 150 mm. in diameter, from the ambitus to the actinal system there are 17 interambulacral and 27 ambulacral plates, and between the ambitus and the abactinal system, 25 interambulacral and 47 ambulacral plates. The plates of the ambulacral areas are thus seen to increase in number much more rapidly than the interambulacral plates.

The specimens, which range from 20 to 150 mm. in diameter, were taken by the "Albatross" at the following stations:

Station 4875. Eastern channel, Korea Strait; 34° 19′ N., 130° 9′ E. 59 fathoms. Fne. gy. s., brk. sh.

Station 4876. Eastern channel, Korea Strait; 34° 20′ N., 130° 10′ E. Bott. temp. 62.1°. 59 fathoms. Fne. gy. s., brk. sh.

Station 4877. Eastern channel, Korea Strait; 34° 20′ 30″ N., 130° 11′ E. 59 fathoms. Fne. gy. s., brk. sh.

Station 4880. Eastern channel, Korea Strait; 34° 16′ N., 130° 16′ E. 59 fathoms. Fne. gy. s., brk. sh.

Station 4946. Between Kagoshima and Kobe, Japan; 31° 29′ 10″ N., 130° 34′ 30″ E. Bott. temp. 68.7°. 39 fathoms. Br. s., brk. sh., p.

Station 5095. In Uraga Strait, Gulf of Tokyo, Japan; 35° 5′ 34″ N., 139° 38′ 36″ E. Bott. temp. 57.8°. 58 fathoms. Fne. bl. s., brk. sh.

Bathymetrical range, 39–59 fathoms. Extremes of temperature, 68.7°–57.8°.

Eleven specimens.

Sperosoma.

Kœhler, 1897. Zool. Anz. XX, p. 302.
Type-species, *Sperosoma Grimaldii* Kœhler, l. c.

The general appearance of Sperosoma is much like that of Echinosoma, the test being, as in that genus, thin and flexible with little difference between the upper and lower sides. The spines and tubercles of the actinal side are larger than those above and the primaries have well-developed hoofs. The actinal tube-feet are in three distinct series and have small sucking-discs or none. The sphæridia are as in Echinosoma. Although the characteristic actinal ambulacra are very remarkable and serve well to distinguish the genus, it must not be supposed that the separation of the primary ambulacral plate into an outer poriferous and an inner non-poriferous part is a feature confined to Sperosoma. Many specimens of *Echinosoma tenue* (and doubtless other members of that genus) show the same phenomenon to a greater or less degree. It is quite common in *tenue* to find the inner and outer halves of the primary plate separated by a suture, even though narrowly in contact, and occasionally the two secondary elements nearly, if not quite, meet between them. This formation of plates by resorption is one of the characters in which the Echinothuridæ are most unique. The essential difference between Sperosoma and Echinosoma in the structure of the ambulacrum is in the *position* of its component parts; thus although the primary plate of Echinosoma may be divided into two parts, there are not four columns of plates in each half-ambulacrum, for the upper (outer) secondary element lies above the outer half of the primary plate and is more or less extensively a part of the interambulacral margin of the ambulacrum. In Sperosoma, the outer halves of the primary plates lie one above the other, broadly in contact, and forming the outer of the four half-ambulacral columns. In Echinosoma this is not the case, the outer column consisting of outer halves of primaries alternating with the upper secondary plate elements, more or less irregularly. The existence of a pair of median columns of imperforate ambulacral plates is a feature in which Sperosoma is absolutely unique among all recent regular Echini, but when we recognize the origin of the plates which compose them, we see that it is not so much their presence, as the way in which they are formed, that is really remarkable. In well-preserved specimens one can

trace (as Mortensen ("Ingolf" Ech. II, p. 171, fig. 27) has done in a very young specimen) the development of the ambulacral plates from their origin next the ocular plate, where we find a primary with a secondary element above and another below it, the three of nearly equal size; through the stage where the primary is much the largest and much wider than high, while the upper secondary has taken an outer, the lower an inner position; through another stage where the secondary elements have so encroached on the primary that the outer and inner halves are only narrowly connected, the pore-pair being in the outer half; to the full four-column arrangement of the actinal side, where the plates are more or less nearly of a size and the distinction between primary and secondary elements is almost obliterated.

Mortensen (1903, "Ingolf" Ech., I, p. 63) says of Sperosoma that sucking-discs are well developed on the feet. We judge this is a slip of the pen, for observation on many specimens indicates that they are wanting, or rudimentary, as shown in his Pl. XIV, fig. 4.

There seem to be six recognizable species in this genus, which may be distinguished as follows:

Abactinal ambulacral plates not twice as numerous as actinal.
- Primary spines of abactinal surface numerous, 150–500 or more in specimens over 100 mm. h. d.
  - Abactinal tube-feet few in an imperfect double series; poriferous zone very narrow; actinal primary spines rather less than 150 . . . . *Grimaldii.*
  - Abactinal tube-feet more numerous in three unequal series, a more or less distinct quincunx arrangement being evident; poriferous zones often quite broad; actinal primary spines rather more than 150 . . . . *quincunciale.*
- Primary spines of abactinal surface few, never exceeding 125 and usually fewer than 75, sometimes nearly or quite wanting.
  - Abactinal primary tubercles very small or wanting; ambulacra much wider than interambulacra . . . . *giganteum.*
  - Abactinal primary tubercles large, with areolæ often occupying whole height of plate; ambulacra about as wide as interambulacra . . . . *obscurum.*

Abactinal ambulacral plates more than twice as numerous as actinal.
- Abactinal tube-feet in two distinct series; no ambulacral plates extending across an entire half-ambulacrum . . . . *biseriatum.*
- Abactinal tube-feet in a single crowded series; some ambulacral plates extend across the entire half-ambulacrum . . . . . . *durum.*

Sperosoma Grimaldii Kœhler.

Sperosoma Grimaldii Kœhler, 1897. Zool. Anz., XX, p. 302. 1898, "Hirondelle" Ech., Pls. II, III, etc.

North Atlantic; 165–930 fathoms.

In addition to one of the "Thor" specimens, received in exchange from the Copenhagen Museum, there lies before us a specimen of Sperosoma taken by the "Blake" off Barbados in 399 fathoms. This specimen is only 110 mm. in diameter, but the structure of the actinal ambulacra is the same as in large specimens. The color is reddish purple. This specimen had been identified as "*Phormosoma Petersii*," no part of an actinal ambulacrum having been cleaned for examination of the plates, and the general facies being very much like *Petersii*. Its pedicellariæ are all rather small and agree well with Mortensen's figures of those of *Grimaldii*. The "Thor" specimen has some very large pedicellariæ, but they are widely scattered; the smaller ones are rather different in form from the published figures, the base of the valves being somewhat swollen.

Sperosoma quincunciale de Meij.

Sperosoma quincunciale de Meijere, 1904. "Siboga" Ech., p. 40; Pl, XIII. figs. *166–176*.

South of Timor; 490 fathoms.

The specimens before us, except for some diversity in color and in the arrangement of the feet abactinally, agree well with de Meijere's description. While the general coloration is distinctly violet of some shade, two or three of the specimens have the abactinal surface and the actinal spines quite yellow. None of the specimens are as large as de Meijere's type. They range from 140 to 170 mm. in diameter. In most of the specimens the tube-feet show the quincunx arrangement abactinally quite plainly, but in one or two specimens the foot on the upper secondary plate-element, instead of being on the same level as that of the lower secondary element of the plate above, is decidedly below it, and the quincunx arrangement, is thereby obscured, the first impression being that of a zigzag line of feet. In other respects these specimens are normal, and we see no reason to consider this peculiarity other than individual variation. The actinal primary spines are provided with large and conspicuous white "hoofs."

Many of the actinal primary spines of these Japanese specimens are infested with a parasitic copepod, apparently identical with *Echinocheres globosus*

Hansen, which Mortensen found in the spines of *Aræosoma gracile.* They produce a swelling in the shaft of the spine, with a small opening at the distal end, giving water access to the cavity in which the animal lives. Not rarely there are two of these parasites in the shaft of a single spine.

The "Albatross" took the species at the following stations:

Station 4957. Between Kagoshima and Kobe, Japan; 32° 36′ N., 132° 23′ E. Bott. temp. 39.8°. 437 fathoms. Gn.-bn. m., fne. gy. s., for.

Station 5079. Off Omai Saki, Japan; 34° 15′ N., 138° E. Bott. temp. 39.1°. 475–505 fathoms. P.

Station 5080. Off Omai Saki, Japan; 34° 10′ 30″ N., 138° 40′ E. Bott. temp. 38.7°. 505 fathoms. Fne. gy. s., glob.

Bathymetrical range, 437–505 fathoms. Extremes of temperature, 39.8°–38.7°.

Seven specimens.

Sperosoma giganteum. A. Ag. and Cl.

Sperosoma giganteum. A. Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 120.

Pl. 64, figs. *9–12*; 65, figs. *1–3*; 83–86.

This remarkable sea urchin measures nearly 320 mm. in its greatest diameter. The color is deep purple, almost black. The ambulacral area is extraordinarily wide, for on the abactinal surface just above the ambitus it measures over 110 mm., while the interambulacrum is a little over 80 mm. (Pl. 83). The outer and inner columns in each half of each ambulacrum are made up of remarkably long low plates, which just above the ambitus are 25 mm. long and only 5 mm. high (Pls. 83, 86, fig. *2*). There are no primary tubercles above the ambitus, but the whole abactinal surface is rather closely covered with slender secondaries and miliaries (Pl. 83). On the actinal surface (Pls. 84, 86, fig. *1*) primary spines are fairly numerous but irregularly placed, showing no regular arrangement. Many ambulacral plates have two, and many interambulacral plates four, spines. The areolæ are small (Pl. 86, fig. *1*), the diameter usually less than half the height of the plate. The primary spines of the actinal surface are nearly all broken off; the remaining ones are seldom 25 mm. long, and terminate in a conspicuous white hoof (Pl. 84).

Both the actinal and abactinal systems of this species (Pl. 85, figs. *2*, *1*) differ greatly from the figures given by Kœhler of *S. Grimaldii,* as well as

those by Döderlein of *S. biseriatum* and those here given of *S. obscurum* (Pl. 89).

The actinal system of *S. Grimaldii* as figured by Kœhler shows its plates to be closely packed with small secondaries arranged horizontally completely connecting the sutures; nor does Kœhler figure any actinostomal ambulacral pores. The actinostomal ambulacral plates of *S. giganteum* (Pl. 85, fig. *2*) are, on the contrary, well separated, arranged in ten vertical series.

In all the other species of Sperosoma, of which the abactinal system has been figured, the genital and ocular plates are most distinct, and while each genital is made up of many plates, it is a simple matter to distinguish them from the anal plates. However, such is not the case in *S. giganteum*, for it seems impossible in the maze of polygonal anal plates, with their close granulation (Pl. 85, fig. *1*) encroaching upon the broken genital and ocular plates, to distinguish the limits of the latter. It is of course possible that this great breaking up of the plates of the abactinal system may be due to age. The madreporic plate is irregularly circular, surrounded with small plates and edged with miliaries. It is the only genital one can trace with any certainty (Pl. 85, fig. *1*), and of the oculars, the left posterior is the only one at all distinct.

The pedicellariæ are interesting, for in addition to tridentate pedicellariæ similar to those of *S. biseriatum* Död. (but seldom with valves as much as two millimeters long) we find ophicephalous and triphyllous pedicellariæ abundant. The latter are not peculiar, but the former are almost exactly like those figured by Mortensen (1903, Pl. 14, fig. *23*) as characteristic of his proposed new genus "Tromikosoma"! In no other respect, however, does this species resemble that group. All the pedicellariæ are numerous but small. The tridentate and triphyllous occur practically everywhere, but the ophicephalous seem to be confined to the ambital region.

The *tridentate* (Pl. 64, fig. *9*) are provided with comparatively short stalks and have a very short neck; the stalks slightly exceed the head in large examples, but are three or four times the head in small ones. The valves (Pl. 64, figs. *10–11*) range from .40 to 1.20 mm., but are most commonly less than a millimeter. They are blunt, often decidedly rounded at tip, and the margins are very slightly sinuate, or a little concave at the base of the blade. In large examples there is more or less of a calcareous mesh-work in the blade.

The *triphyllous* pedicellariæ are not peculiar, save that the valves (Pl. 64, fig. *12*) are rather wide, with a fairly well developed and apparently imperforate cover-plate; they measure about half a millimeter in length and more than half that in width at the tip.

The *ophicephalous* pedicellariæ (Pl. 65, figs. *1*, *2*) are very common on the abactinal surface, just above the ambitus, but become less common as we pass toward either pole, and are practically wanting at a distance of 75 mm. from the ambitus. The stalks are three or four times as long as the heads. The valves (Pl. 65, fig. *3*) are .60–.70 mm. in length and have the form usual in the Echinothuridæ.

The sphæridia and calcareous spicules (perforated plates) in the tube-feet show no noteworthy features.

The single specimen of this species was taken by the "Albatross" at the following station:

Station 5082. Off Omai Saki Light, Honshu Island, Japan; 34° 5′ N., 137° 59′ E. Bott. temp. 37.7°. 662 fathoms. Gn. m., fne. s., glob.

Sperosoma obscurum A. Ag. and Cl.

Sperosoma obscurum A. Agassiz and Clark, 1907. Bull. M. C. Z., L., p. 239.

Plates 62, fig. *4*; 63, fig. *1*; 65, figs. *4–14*; 87–89.

A large number of specimens of Sperosoma were collected among the Hawaiian Islands, which could not be referred to any previously known species of the genus. In a specimen measuring 169 mm. in diameter there are 19 interambulacral plates (Pl. 87) between the ambitus and the abactinal system in each column, and 25 ambulacral plates. At the ambitus the interambulacral area measures 55 mm. across and the ambulacral 50. On the abactinal surface there are comparatively few primary tubercles, forming irregular vertical rows on each side of the interambulacral area. They have large scrobicular circles (Pl. 87), and carry comparatively stout spines. The rest of the abactinal surface of the test is covered with distant small, sharp, and slender secondary and miliary spines (Pl. 89, fig. *4*).

On the actinal side there are 18 ambulacral and 13 interambulacral plates between the actinal system and the ambitus. Each of the central ambulacral plates near the ambitus carries one large primary tubercle (Pls. 88, 89, fig. *3*), and in the interambulacral area (Pls. 88, 89, fig. *4*) there is one at each extremity of the plate.

The pores on the abactinal surface are arranged in a double series on each side of the ambulacrum, but the outer series contains fifty per cent more pores than the inner, and a quincunx arrangement is seldom visible (Pl. 89, fig. *4*). The greater part of the actinal surface, especially about the actinostome, is closely covered with small tubercles of more or less uniform size (Pls. 88, 89, fig. *1*), giving an appearance not wholly unlike *Chætodiadema;* this is most marked in large individuals.

The actinal system (Pl. 89, fig. *1*) is well covered by about eight concentric series of narrow plates, each carrying one row of small secondaries; the plates decrease rapidly in size adorally and leave small bare areas between the adjoining ambulacra close to the mouth.

In the abactinal system (Pl. 89, fig. *2*) the ocular plates are comparatively small, with distinct pores, and each carries two or three miliaries or secondaries. In the specimen figured three of the genital plates are well limited, and each carries from two to six small secondaries and miliaries. With the other genitals, one cannot separate the plates of the anal system from those which may be small proximal parts of the genital plates. The genital pore is about in the centre of an elongate rectangular membrane extending well down between the columns of abactinal interambulacral plates. There are three to five rows of irregularly shaped small anal plates, each carrying one or two small secondaries or miliaries.

The coloration of this species is rather variable, for while most of the specimens are more or less decidedly violet or purple, some large ones are distinctly gray or yellowish-brown; the plates, at least abactinally, are frequently quite plainly outlined in a shade darker than the rest of the test.

The pedicellariæ are abundant and rather characteristic. No ophicephalous pedicellariæ were found. The *tridentate* pedicellariæ (Pl. 65, figs. *4*, *5*) occur everywhere and in very diverse sizes. The stalks (Pl. 65, fig. 7) are usually twice the length of the head, and may be three or four times as long. The valves (Pl. 65, figs. *6*, *9*, *10*) are slender, often very slender, compressed, in contact distally, and usually well separated at the base; the lateral margin is broadly curved where the blade joins the base (fig. *10*); much more rarely the blades are in contact for most of their length, and the lateral margins are abruptly curved in (fig. *9*) where the blade joins the base. The valves range in length from half a millimeter to nearly three millimeters.

The *triphyllous* pedicellariæ are abundant everywhere. The necks are long and slender, often three times as long as the head, and the stalks (Pl. 65, fig. *8*) may be twice as long as the neck or even longer. The valves (Pl. 65, figs. *11*, *12*) are somewhat variable in form and proportions; they are one-third to one-half a millimeter in length, and the tip may be rather abruptly truncate, and in width considerably more than half the length, or it may be more rounded and in width less than half the length. The cover-plate is perforated but is only slightly developed.

The *sphæridia* (Pl. 65, fig. *13*) are rather large and occur well up on to the abactinal side. The *calcareous plates* (Pl. 65, fig. *14*) in the tube-feet are rather small but fairly abundant.

This species was taken by the "Albatross" at the following stations, the specimens ranging from 20 to 220 mm. in diameter:

Station 3824. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 49.5°. 222–498 fathoms. Co., r., brk. sh.

Station 3865. Between Maui and Molokai, H. I. Bott. temp. 44.8°–45°. 256–283 fathoms. Fne. vol. s., r.

Station 3979. Off Modu Manu, H. I. Bott. temp. 54°. 222–387 fathoms. Fne. wh. s., for., r.

Station 3988. Off Hanamaulu, Kauai, H. I. Bott. temp. 40°. 165–469 fathoms. Gy. for., s., p.

Station 4015. Off Hanamaulu, Kauai, H. I. Bott. temp. 41.2°. 318–362 fathoms. Gy. s., r.

Station 4021. Off Hanamaulu, Kauai, H. I. Bott. temp. 44°. 286–399 fathoms. Co. s., for.

Station 4025. Off Mokuaeae Point, Kauai, H. I. Bott. temp. 44.9°. 275–368 fathoms. Fne. gy. s., brk. sh., for.

Station 4036. Off Kawaihae Light, Hawaii, H. I. Bott. temp. 38.2°. 687–692 fathoms. Fne. dk. gy. s., for.

Station 4089. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 43.8°. 297–304 fathoms. Fne. gy. s.

Station 4096. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Station 4112. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 40.5°. 433–447 fathoms. Fne. s.

Station 4117. Off Kahuku Point, Oahu, H. I. Bott. temp. 45.6°. 253–282 fathoms. Co. s., for.

Station 4130. Off Hanamaulu, Kauai, H. I. Bott. temp. 46.1°. 283–309 fathoms. Fne. gy. s.

Station 4131. Off Hanamaulu, Kauai, H. I. Bott. temp. 43.7°. 257–309 fathoms. Fne. gy. s.

Station 4134. Off Hanamaulu, Kauai, H. I. Bott. temp. 43.3°. 225–324 fathoms. Fne. co. vol. s.

Station 4136. Off Hanamaulu, Kauai, H. I. Bott. temp. 44.2°. 294–352 fathoms. Fne. co. s.

Station 4137. Off Hanamaulu, Kauai, H. I. Bott. temp. 41°. 411–476 fathoms. Co., vol. s., for., r.

Bathymetrical range, 165–692 fathoms. Extremes of temperature, 54°–38.2°.

Thirty-nine specimens.

Sperosoma biseriatum Död.

Sperosoma biseriatum Döderlein, 1901. Zool. Anz., XXIII, p. 20. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XIX; XL, figs. *1–1h*.
Sperosoma biseriatum Agassiz and Clark, 1907. Bull. M. C. Z., LI, p. 120.

Western Indian Ocean; 563 fathoms.

Plate 65, figs. *15–20*.

The specimen which we have referred to this species differs very markedly from Döderlein's type, and, taking these differences in connection with the very great geographical and bathymetrical distances between the two specimens, we have little doubt that they are not identical. But in view of the poor condition of our specimen and the fact that in certain important particulars it agrees well with *biseriatum*, it has seemed to us better to let it remain under this name, than to attempt the diagnosis of a new species based upon it.

The test is thicker and tougher than in Döderlein's specimen, and the color, which is a deep violet where the epidermis is not rubbed off, is very different. The pedicellariæ also show some slight differences which we have thought worth figuring. They are very abundant all over the test, but only tridentate and triphyllous were found; there seem to be no ophicephalous ones. The *tridentate* pedicellariæ (Pl. 65, figs. *15*, *16*) have the necks very short and the stalks 2–5 times as long as the head; the valves (fig. *18*) are short and wide, closely in contact for practically their whole

length, and with nearly even, scarcely at all sinuate, margins; the middle of the blade is filled by an extensive calcareous mesh-work; the valves measure from .30–1.40 mm. in length, and the width at base is about two-thirds as much.

The *triphyllous* pedicellariæ (Pl. 65, fig. *17*) are not peculiar, though neck and stalk are both very slender; the valves (fig. *19*) are very much like those of *S. obscurum*, and are about .50 mm. in length.

The *calcareous particles* in the tube-feet (Pl. 65, fig. *20*) are large, perforated plates, half a millimeter more or less in diameter; the largest have rough ridges and projections near the middle. No sphæridia were found.

The single specimen, about 175 mm. in diameter, was taken by the "Albatross" at the following station:

Station 4766. Between Atka Island and Bowers Bank, Bering Sea; 52° 38′ N., 174° 49′ W. 1766 fathoms. Character and temperature of bottom not recorded.

Sperosoma durum Död.

Sperosoma durum Döderlein, 1905. Zool. Anz., XXVIII, p. 621. 1906. Ech. d. deutschen Tiefsee-Exp., Pls. XVIII, figs. *2*, *2a*; XL, figs. *4–4n*.

Western Indian Ocean; 913 fathoms.

In addition to the characters given on p. 195, the deep purple-red color and the presence of ophicephalous pedicellariæ are interesting features of this species, of which only a single specimen, 112 mm. in diameter, is known. The name refers to the character of the test, which is firmer and stouter than in *biseriatum*, particularly abactinally.

EXPLANATION OF THE PLATES.

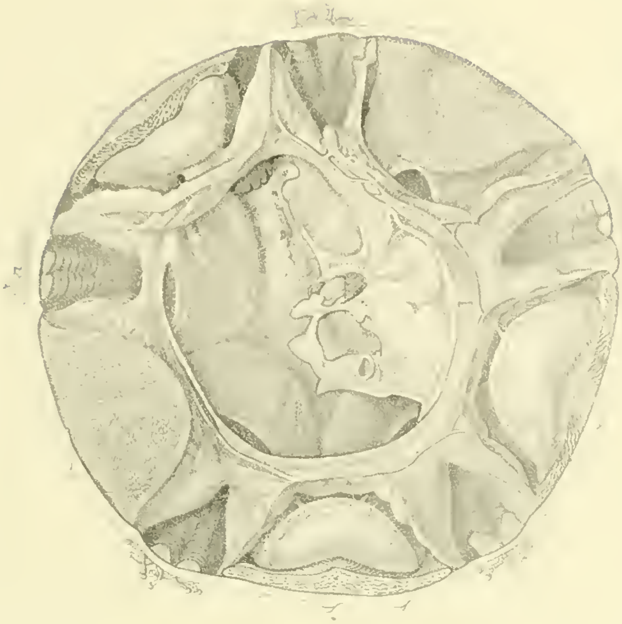
Plate 60.

Plate 60.

Showing some Features of the Internal Anatomy of
Echinothrix diadema Lovén.

1. Interior view, showing arrangement of alimentary canal; actinal half of test and lantern removed.
2. Interior view, showing part of reproductive organs, alimentary canal and perignathic girdle; one side of test removed.
3. Alimentary canal, removed from test; natural position, seen from below.
4. Lantern and perignathic girdle in position, seen from the side, showing the rudimentary Stewart's organ just below the forked end of the compass.

All figures natural size.



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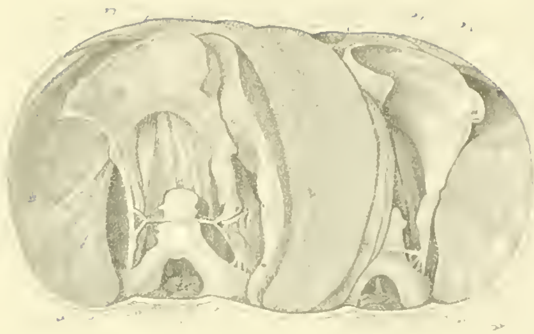

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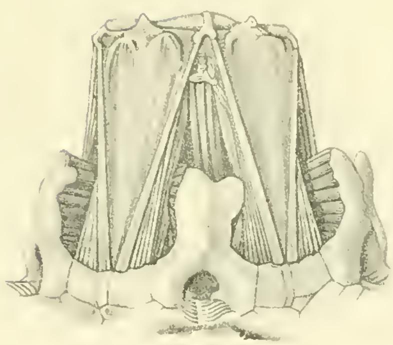

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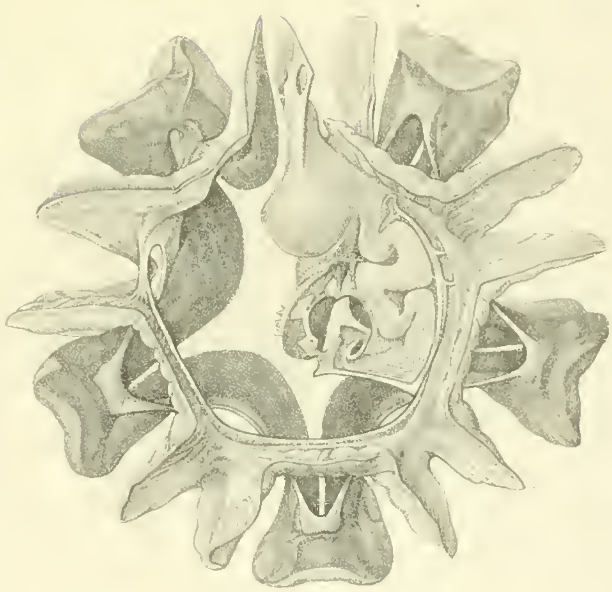

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PLATE 61.

Plate 61.

Showing some Features of the Internal Anatomy of
Astropyga and Micropyga.

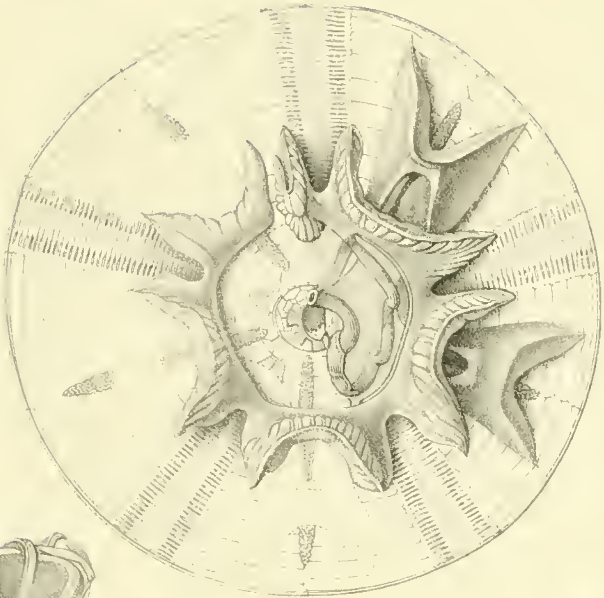
1, 2. **Micropyga tuberculata** A. Ag.

1. Interior view, showing arrangement of alimentary canal; actinal half of test and lantern removed. The dotted lines surrounding unshaded parts are hypothetical, the specimen being somewhat damaged.
2. Lantern and perignathic girdle in position, seen from the side.

3, 4. **Astropyga radiata** Gray.

3. Interior view, showing arrangement of alimentary canal; actinal half of test and lantern removed.
4. Lantern and perignathie girdle in position, seen from the side.

All figures natural size.



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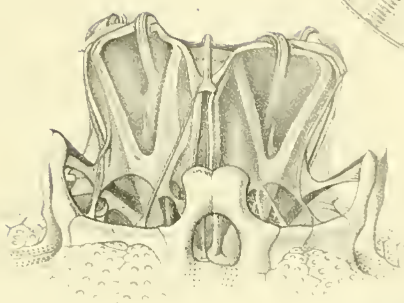

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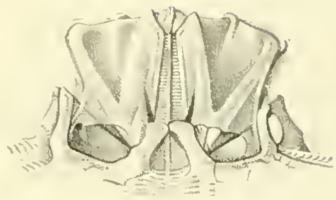

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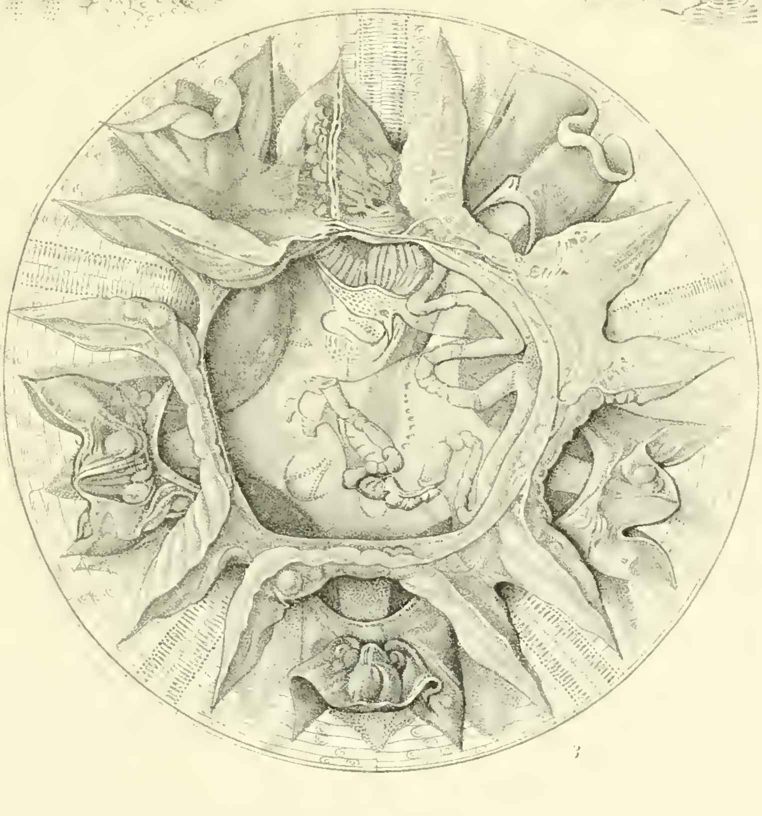

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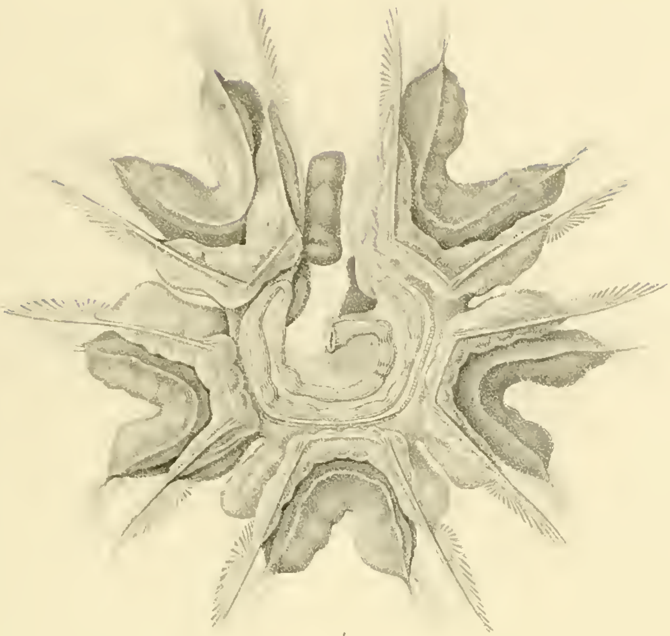
PLATE 62.

Plate 62.

Alimentary canals of Echinothurids, removed from the tests, natural position, seen from below.

1. **Asthenosoma Ijimai** Yosh.
2. **Phormosoma bursarium** A. Ag.
3. **Echinosoma hispidum** Mortens.
4. **Sperosoma obscurum** A. Ag. and Cl.

All figures natural size.



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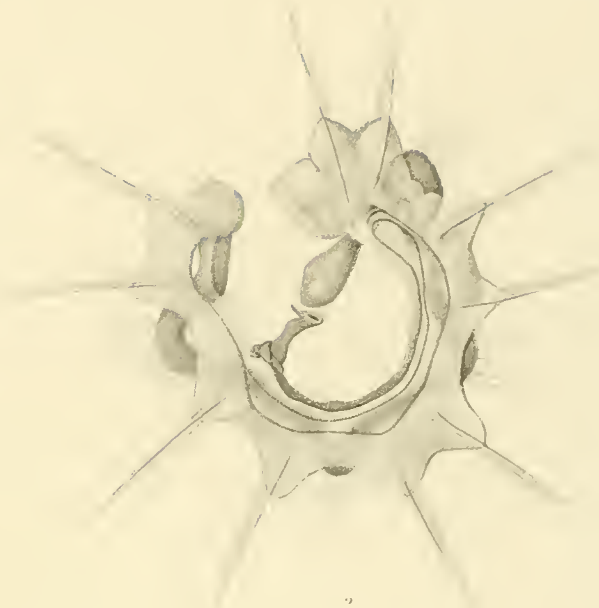

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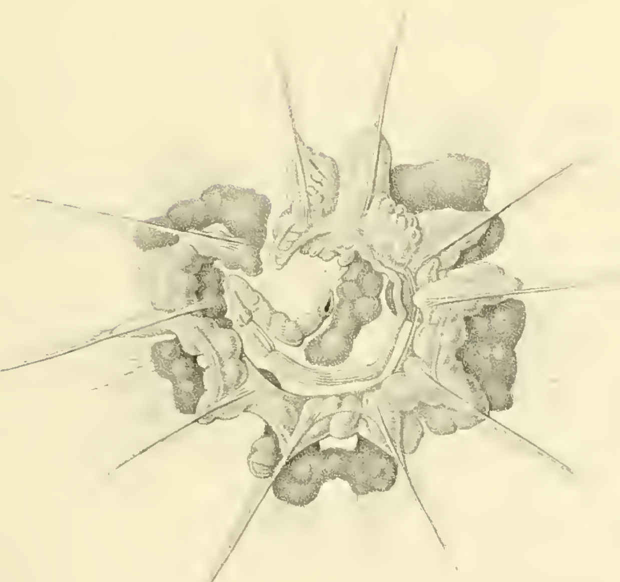

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A.M. Westergren del.

B. Mei…

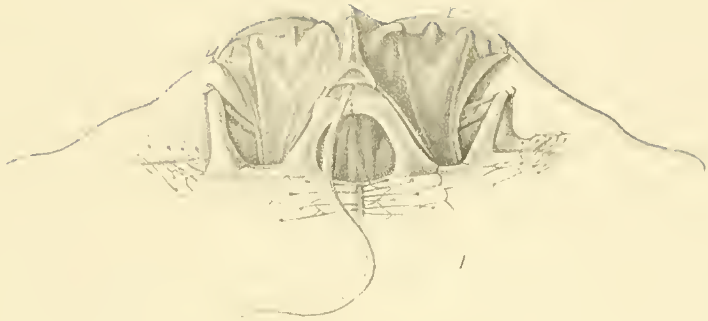
Plate 63.

Plate 63.

Perignathic Girdles, Lanterns, and Stewart's Organs of Echinothurids, in natural position, seen from the side.

1. **Sperosoma obscurum** A. Ag. and Cl.
2. **Asthenosoma Ijimai** Yosh.
3. **Phormosoma bursarium** A. Ag.
4. **Echinosoma hispidum** Mortens.

All figures considerably enlarged.



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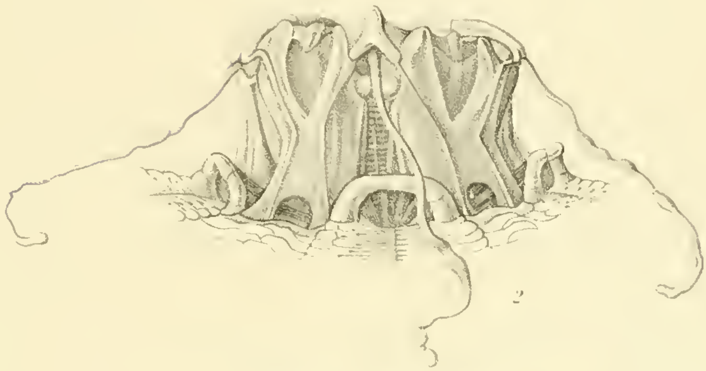

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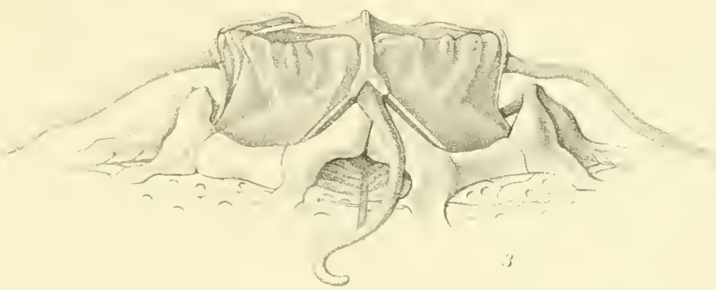

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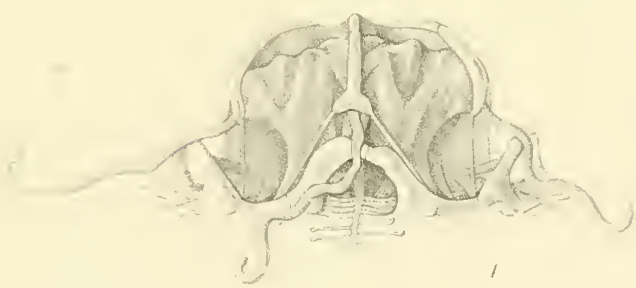

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PLATE 64.

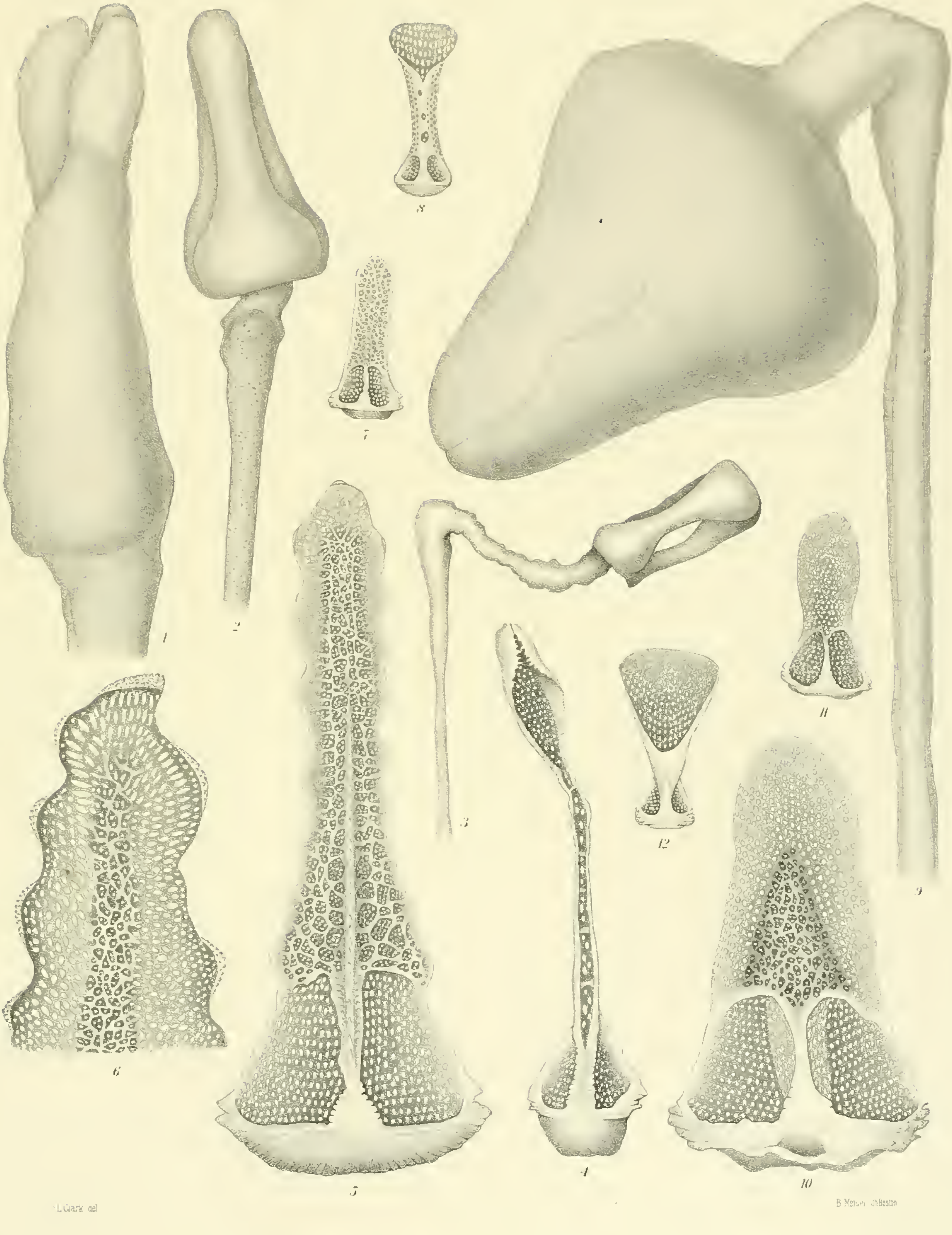
PLATE 64.

1–8. **Aræosoma bicolor** A. Ag. and Cl.

1. Dactylous pedicellaria. × 70.
2. Large tridentate pedicellaria. × 30.
3. Triphyllous pedicellaria. × 70.
4. Valve of dactylous pedicellaria. × 70.
5. Valve of large tridentate pedicellaria. × 70.
6. Tip of valve of large tridentate pedicellaria. × 150.
7. Valve of small tridentate pedicellaria. × 70.
8. Valve of triphyllous pedicellaria. × 70.

9–12. **Sperosoma giganteum** A. Ag. and Cl.

9. Large tridentate pedicellaria. × 70.
10. Valve of large tridentate pedicellaria. × 70.
11. Valve of small tridentate pedicellaria. × 70.
12. Valve of triphyllous pedicellaria. × 70.



L. Clark del.

B. Meisel lith Boston

Plate 65.

Plate 65.

1–3. **Sperosoma giganteum** A. Ag. and Cl.

1. Ophicephalous pedicellaria, seen from the side. × 70.
2. The same, seen from distal end. × 70.
3. Valve of same, seen from within. × 70.

4–14. **Sperosoma obscurum** A. Ag. and Cl.

4. Tridentate pedicellaria, with valves in contact throughout. × 30.
5. Tridentate pedicellaria, with valves in contact only at tip. × 30.
6. Valve of a tridentate pedicellaria like fig. 5. × 70.
7. Stalk of tridentate pedicellaria. × 70.
8. Stalk of triphyllous pedicellaria. × 70.
9. Base of blade of valve of tridentate pedicellaria like fig. 4, side view. × 70.
10. Base of blade of valve of tridentate pedicellaria like fig. 5, side view. × 70.
11. Valve of a triphyllous pedicellaria. × 70.
12. Valve of another triphyllous pedicellaria. × 70.
13. Sphæridium. × 70.
14. Calcareous particles from pedicels. × 70.

15–20. **Sperosoma biseriatum** Död. (?). From Station 4766

15. Large tridentate pedicellaria. × 30.
16. Small tridentate pedicellaria. × 30.
17. Triphyllous pedicellaria. × 30.
18. Valve of tridentate pedicellaria. × 70.
19. Valve of triphyllous pedicellaria. × 70.
20. Calcareous particles from pedicels. × 70.

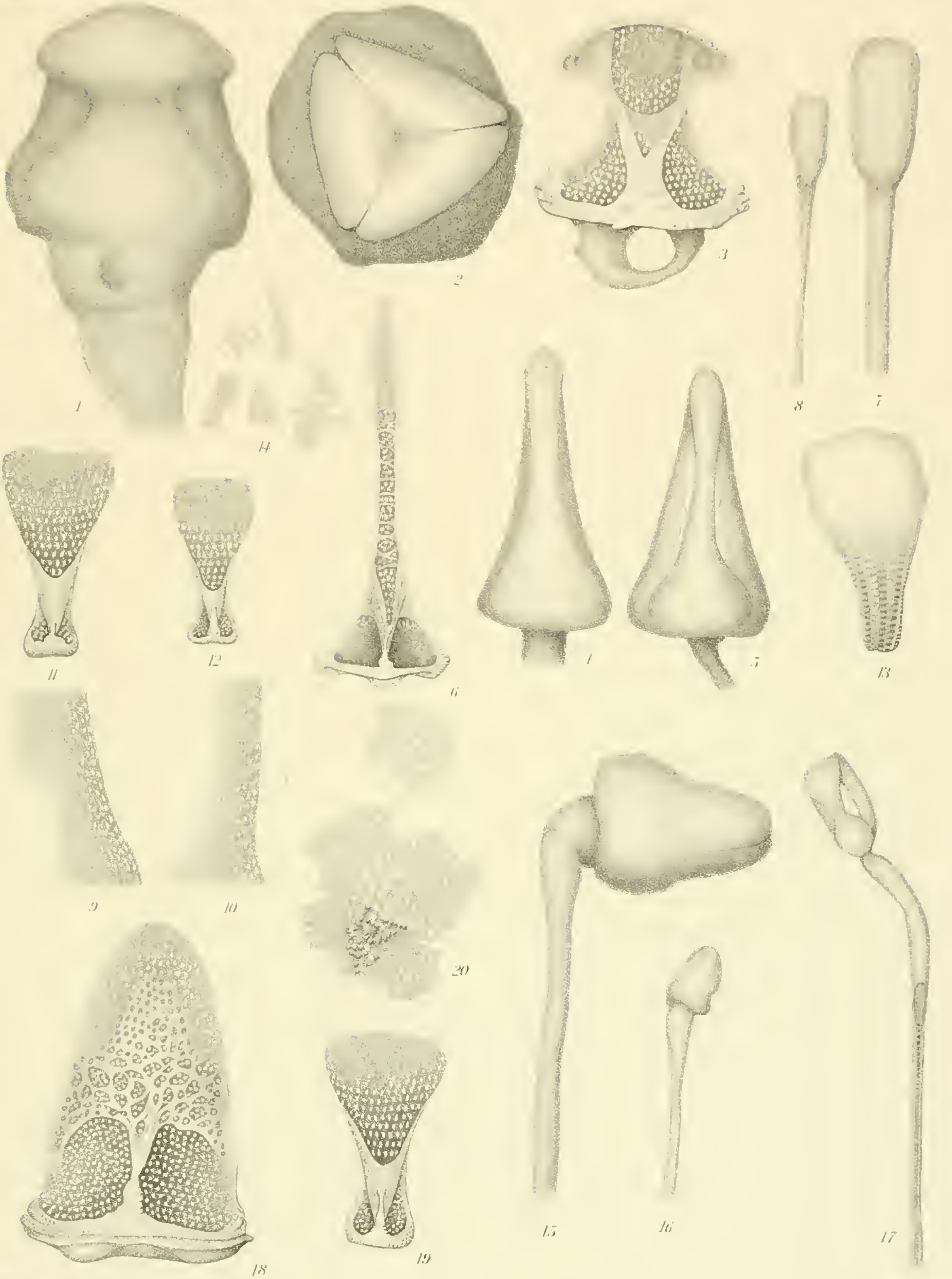

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Plate 66.

Plate 66.

1-4. Aræosoma pyrochloa A. Ag. and Cl.

1. Large tridentate pedicellaria. × 30.
2. Small tridentate pedicellaria. × 30.
3. Triphyllous pedicellaria, with partly open valves. × 30.
4. Sphæridium. × 30.

5. Aræosoma Belli Mortens.

5. Sphæridium. × 70.

6–17. Aræosoma thetidis A. Ag. and Cl.

6. Valve of very small tridentate pedicellaria. × 70.
7–10. Margins of valves of tridentate pedicellariæ. × 70.
11. Blade of valve of large tridentate pedicellaria, from within. × 70.
12. Tip of blade of large tridentate pedicellaria, side view. × 70.
13. Calcareous particles from pedicels. × 70.
14. Valve of triphyllous pedicellaria. × 70.
15. Large tridentate pedicellaria. × 30.
16. Triphyllous pedicellaria. × 30.
17. Tridentate pedicellaria. × 30.

18, 19. Aræosoma eurypatum A. Ag. and Cl.

18. Sphæridia. × 70.
19. Valve of triphyllous pedicellaria. × 70.

20. Aræosoma fenestratum Mortens.

20. Dactylous pedicellaria with *five* valves. × 30.

Plate 67.

PLATE 67.

1–3. Echinosoma panamense Mortens.

1. Triphyllous pedicellaria. × 70.
2, 3. Tridentate pedicellariæ. × 70.

4–11. Echinosoma hispidum Mortens.

4. Large tridentate pedicellaria. × 10.
5. Valve of large tridentate pedicellaria. × 15.
6. Ordinary small tridentate pedicellaria. × 10.
7. Valve of ordinary small tridentate pedicellaria. × 30.
8, 9. Rare forms of small tridentate pedicellariæ. × 10.
10. Triphyllous pedicellaria. × 10.
11. Sphæridium. × 70.

12–15. Echinosoma tenue Pomel. From Station 3784.

12. Large tridentate pedicellaria. × 30.
13. Valve of large tridentate pedicellaria. × 30.
14. Valve of small tridentate pedicellaria. × 70.
15. Valve of triphyllous pedicellaria. × 70.

16–21. Echinosoma tenue Pomel. From Station 5084.

16. Valve of large tridentate pedicellaria. × 30.
17. Small tridentate pedicellaria. × 30.
18. Valve of small tridentate pedicellaria. × 70.
19. Triphyllous pedicellaria. × 30.
20. Valve of triphyllous pedicellaria. × 70.
21. Valve of ophicephalous pedicellaria. × 70.

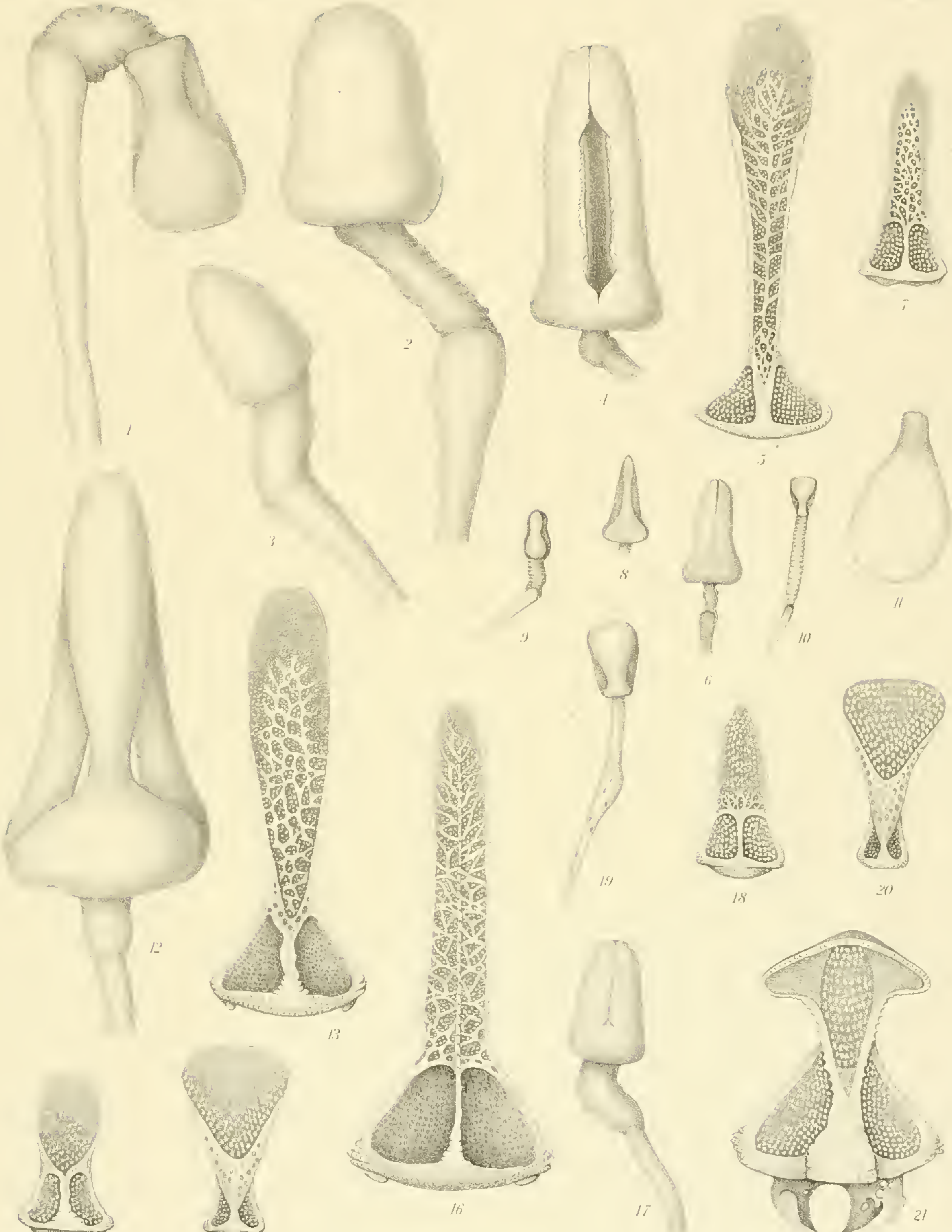
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PLATE 68.

PLATE 68.

Aræosoma thetidis A. Ag. and Cl.

Abactinal view of partly denuded specimen.
Natural size.

Heliotype Co. Boston.

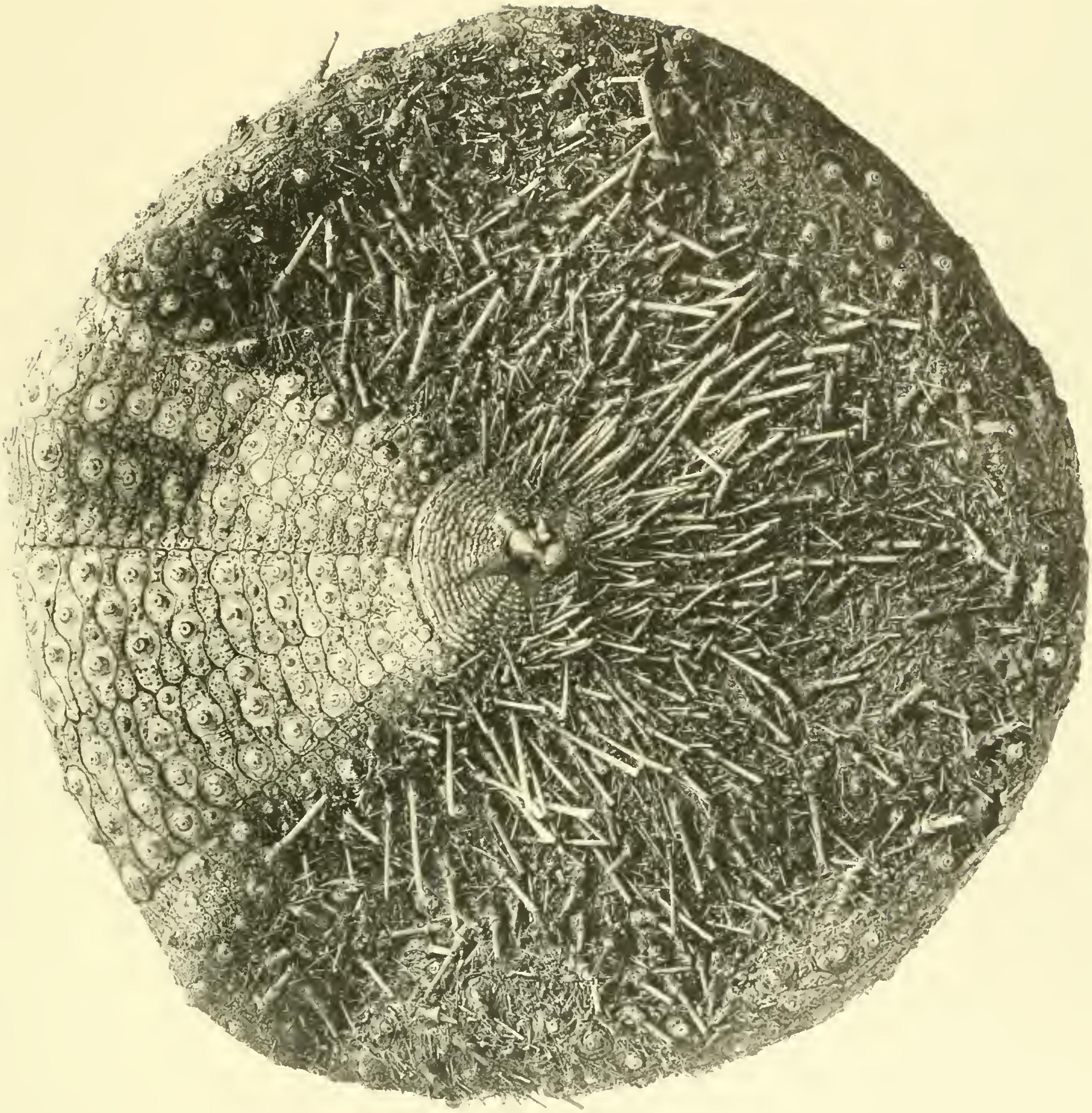
PLATE 69.

PLATE 69.

Aræosoma thetidis A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 68.

Natural size.



Heliotype Co Boston.

PLATE 70.

Plate **70**.

Aræosoma thetidis A. Ag. and Cl.

1. Abactinal system. × 1.7.
2. Actinostome and base of corona. × 1.1.
3. Actinal ambulacral and interambulacral plates, ten millimeters from ambitus. × 1.3.
4. Abactinal ambulacral and interambulacral plates, ten millimeters from ambitus. × 1.1.

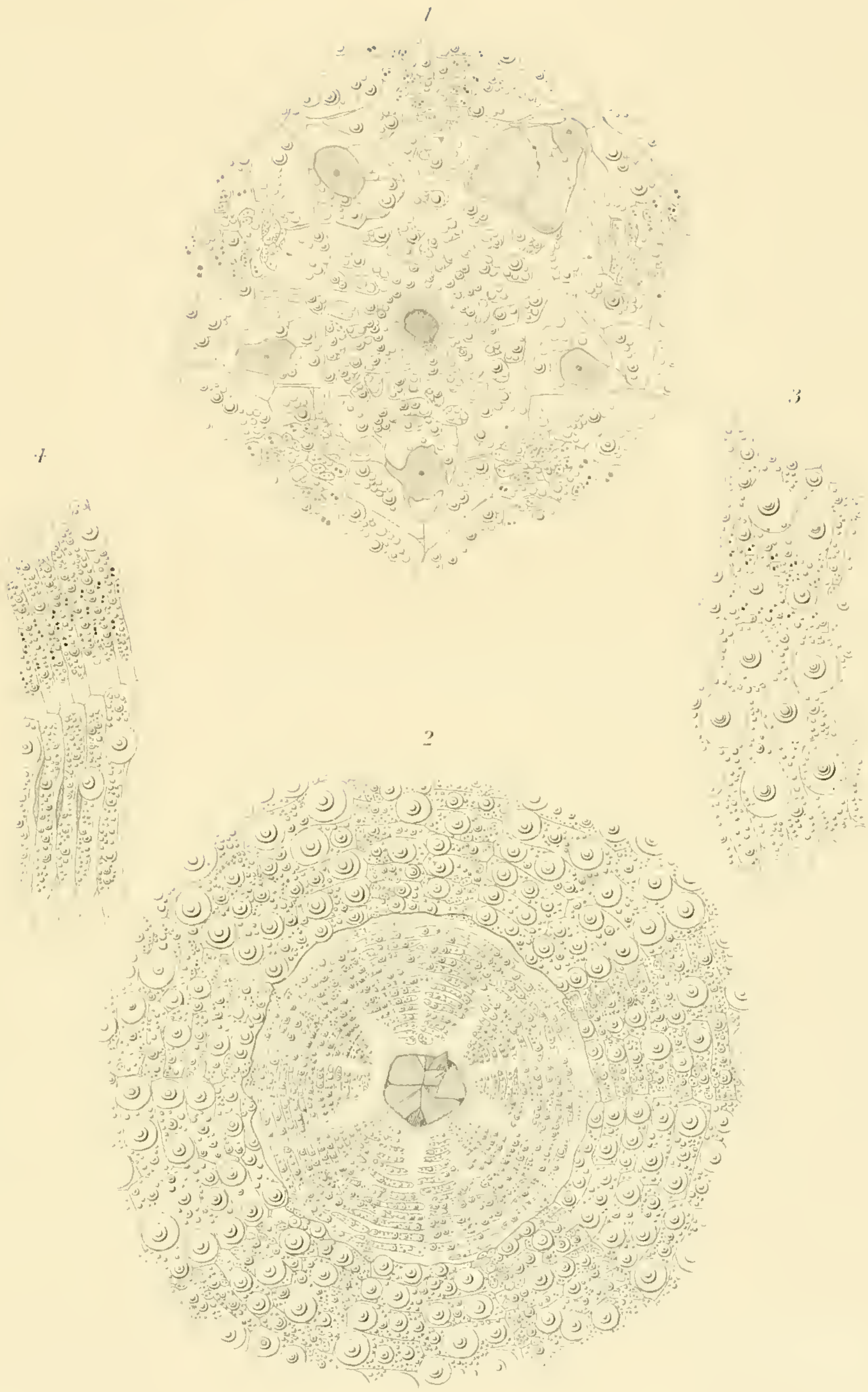

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PLATE 71.

Plate 71.

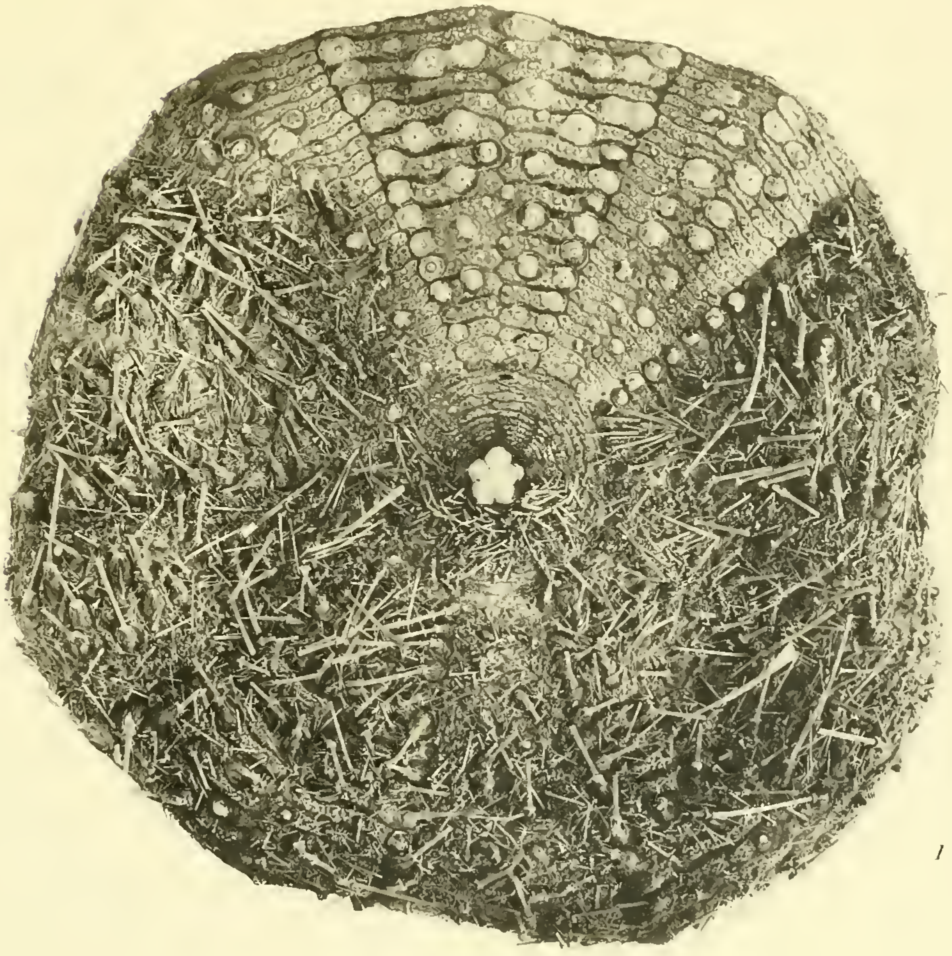
Aræosoma bicolor A. Ag. and Cl.

1. Actinal view of partly denuded specimen.
2. Abactinal view of same.

Natural size.

Owing to an oversight of the printer the position of the figures of this plate has accidentally been reversed. In all the other plates the right anterior interambulacrum is on the right of the anterior or median ambulacrum.

2



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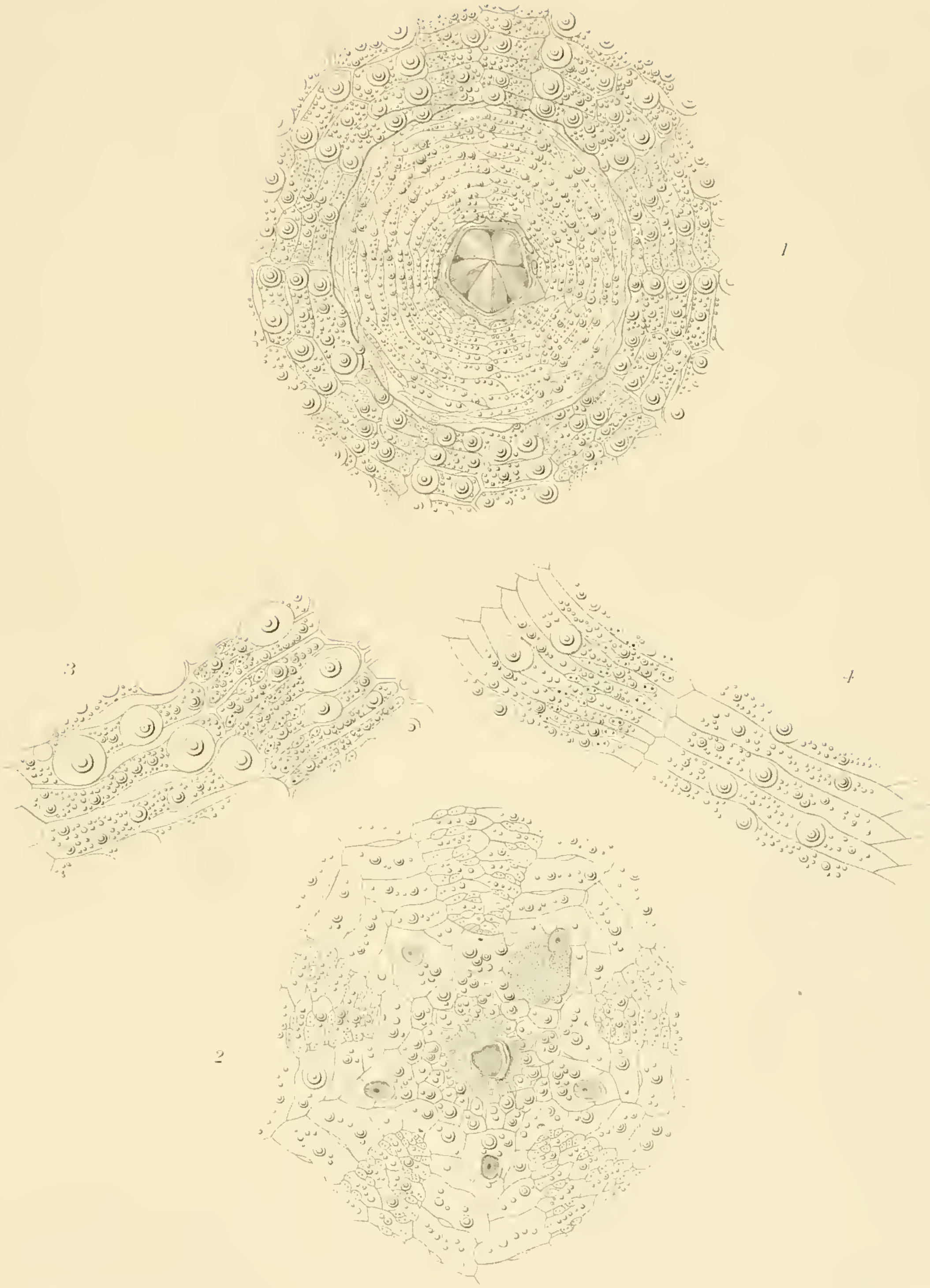
Heliotype Co Boston

PLATE **72**.

Plate 72.

Aræosoma bicolor A. Ag. and Cl.

1. Actinostome and base of corona. × 1.7.
2. Abactinal system. × 2.3.
3. Actinal ambulacral and interambulacral plates, seven millimeters from ambitus. × 1.8.
4. Abactinal ambulacral and interambulacral plates, eight millimeters from ambitus. × 2.



A M [illegible] [illegible] M [illegible]

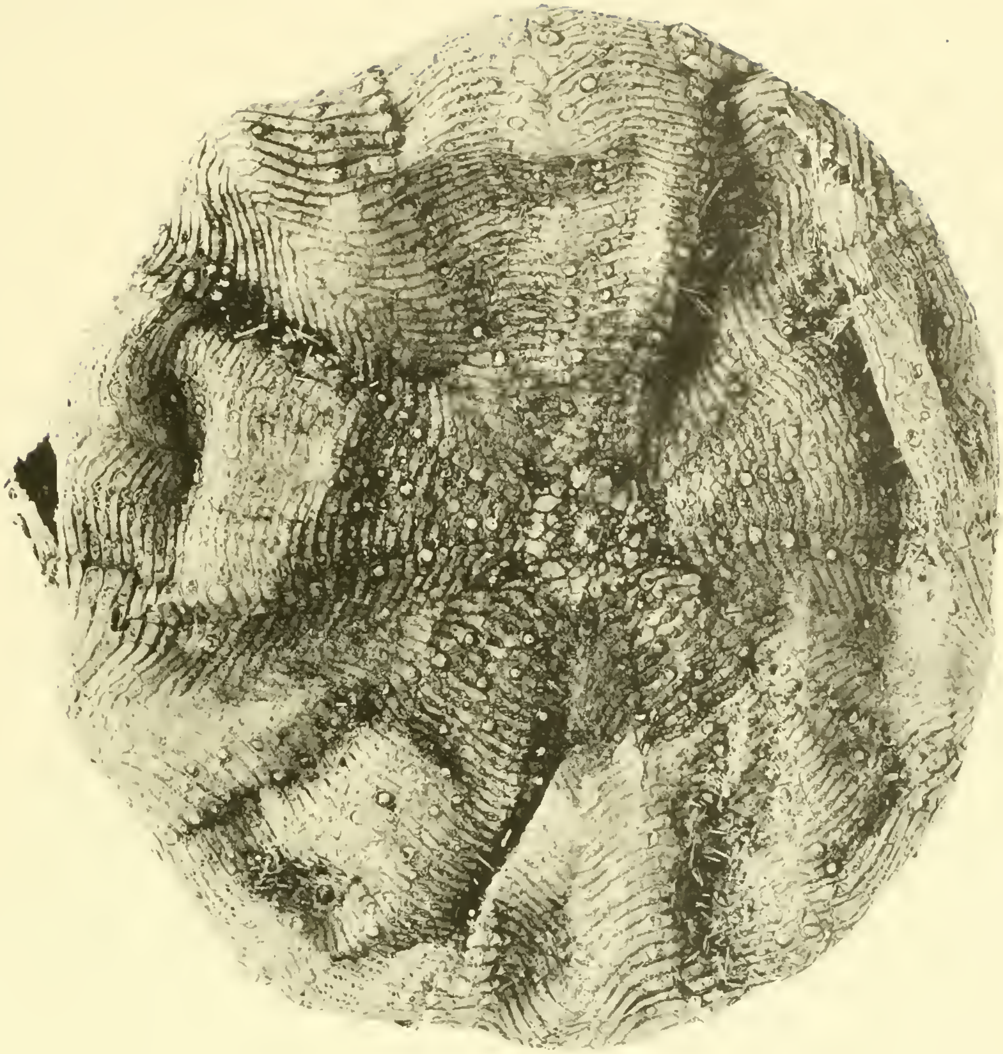
Plate 73.

Plate 73.

Aræosoma eurypatum A. Ag. and Cl.

1. Abactinal view of nearly denuded specimen.
2. Side view of same, looking towards an interambulacrum.

Natural size.



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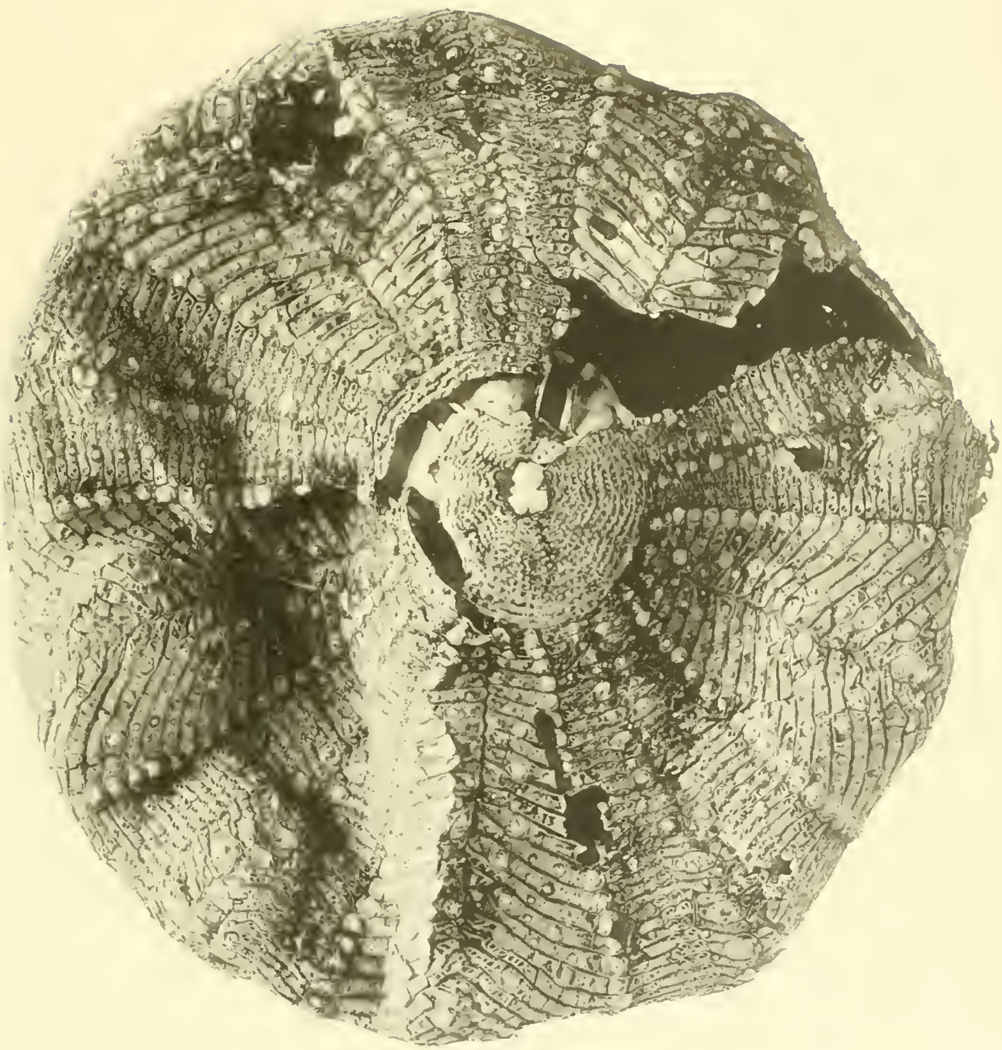
Heliotype Co. Boston.

PLATE 74.

PLATE **74.**

Aræosoma eurypatum A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 73.
Natural size.



Heliotype Co. Boston

Plate 75.

Plate 75.

Aræosoma eurypatum A. Ag. and Cl.

1. Actinostome and base of corona, somewhat damaged. × 1.3.
2. Abactinal system. × 2.
3. Actinal ambulacral and interambulacral plates, five millimeters from ambitus. × 1.5.
4. Abactinal ambulacral and interambulacral plates, just above ambitus. × 1.3.

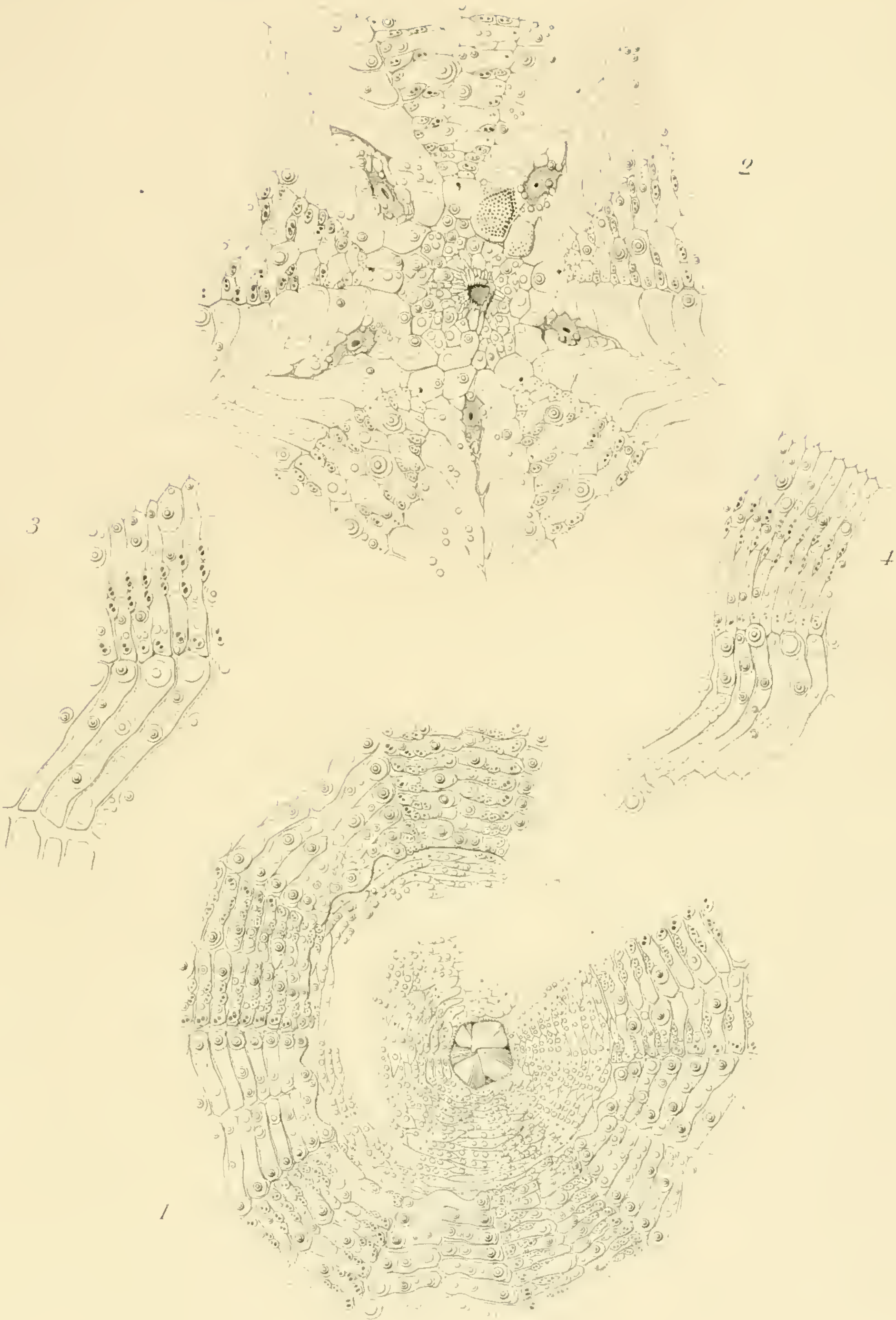


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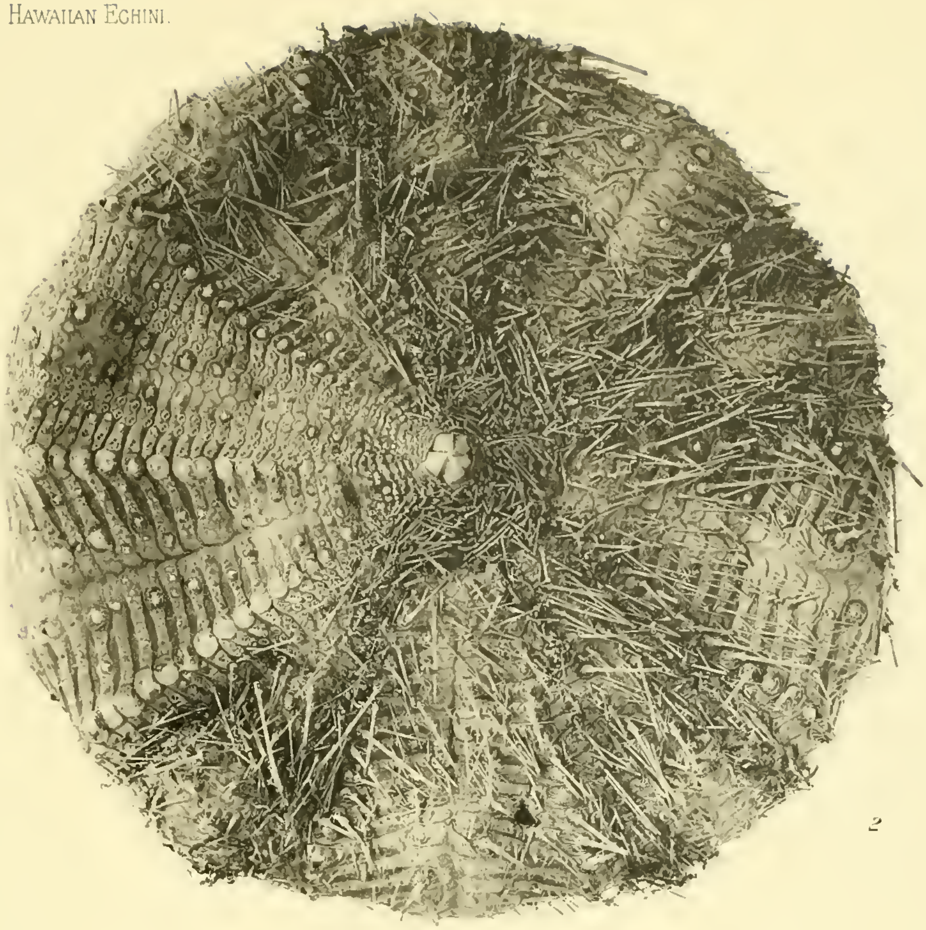
PLATE 76.

Plate 76.

Aræosoma leptaleum A. Ag. and Cl.

1. Abactinal view of partly denuded specimen.
2. Actinal view of same.

Natural size.



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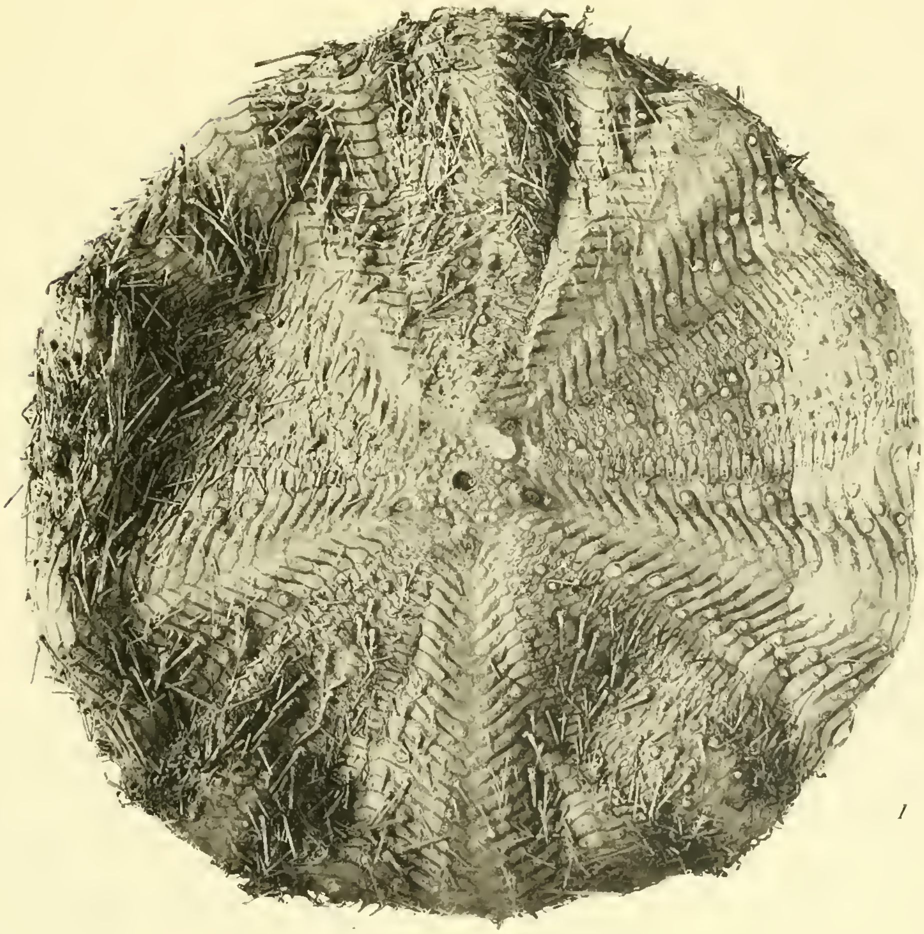

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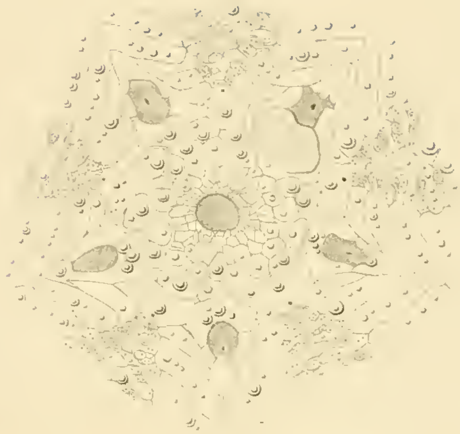
Heliotype Co. Boston.

PLATE 77.

Plate 77.

Aræosoma leptaleum A. Ag. and Cl.

1. Actinostome and base of corona. × 1.8.
2. Abactinal system. × 2.
3. Actinal ambulacral and interambulacral plates twelve millimeters from ambitus. × 1.6.
4. Abactinal ambulacral and interambulacral plates eight millimeters from ambitus. × 2.



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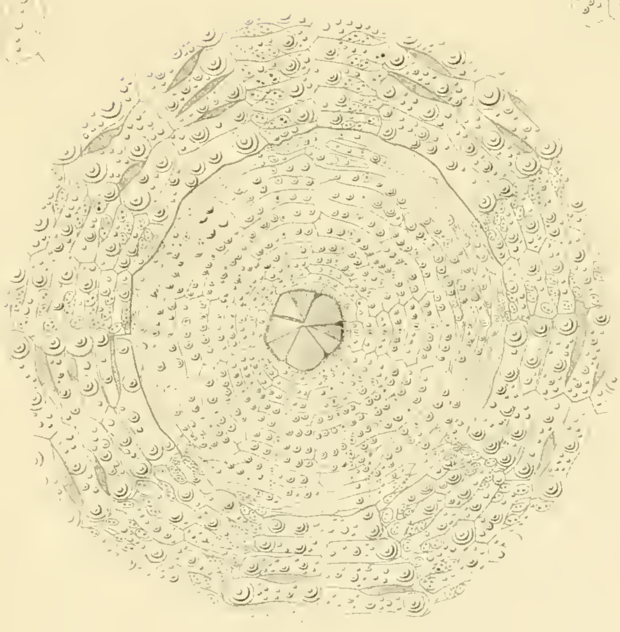

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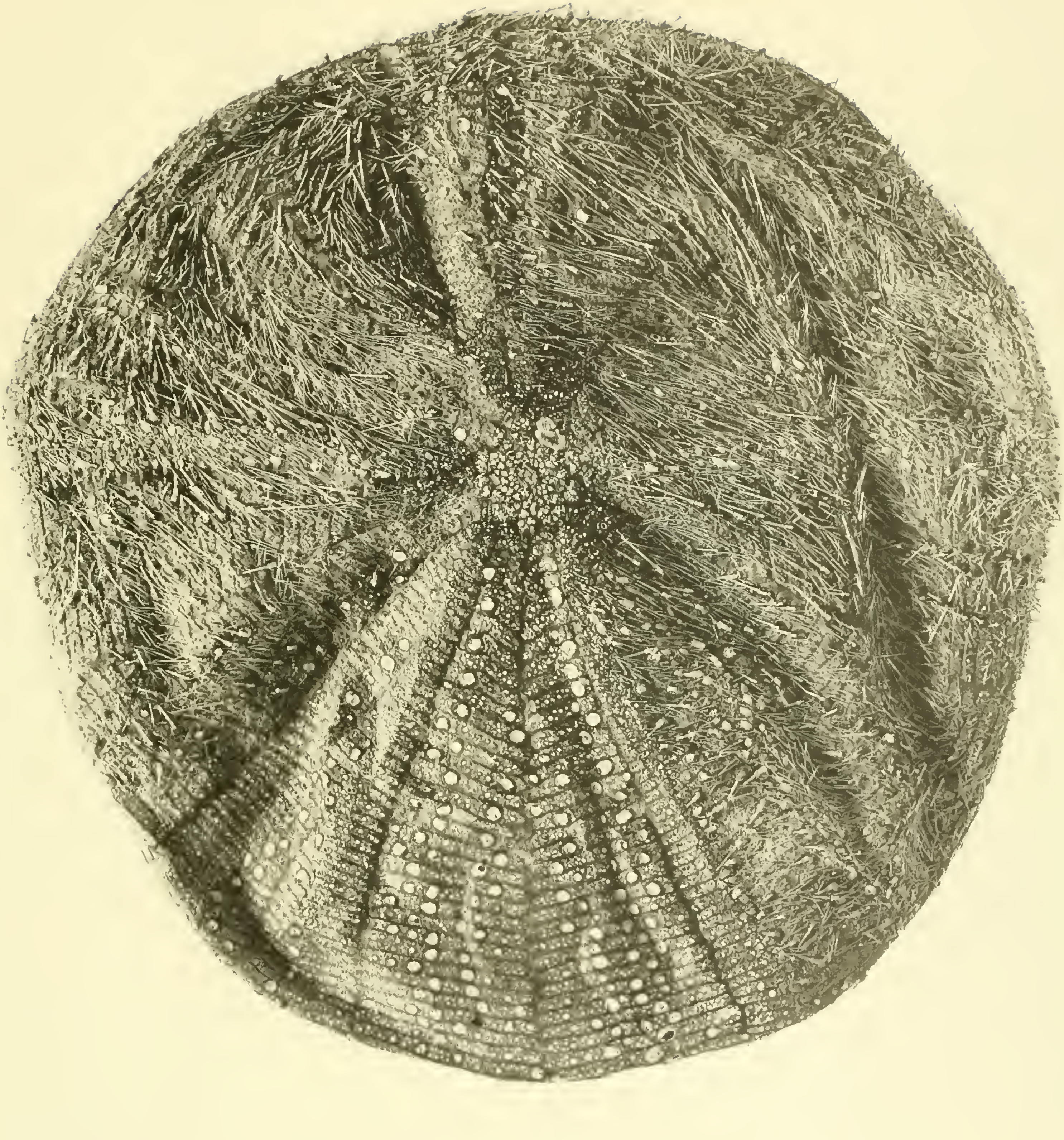
A. M. ... gen

Plate 78.

PLATE 78.

Aræosoma pyrochloa A. Ag. and Cl.

Abactinal view of partly denuded specimen.
Natural size.



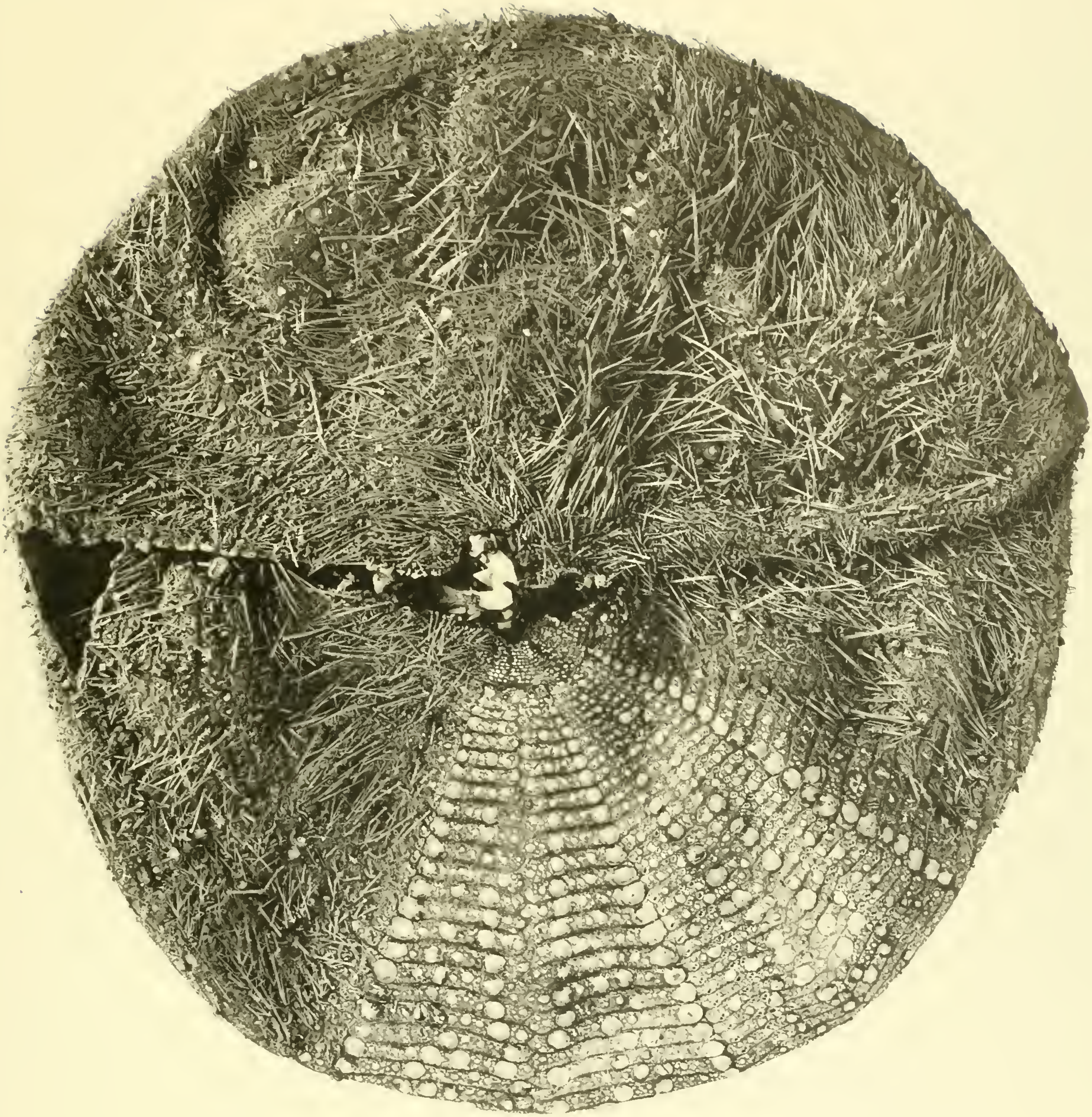
Heliotype Co. Boston.

PLATE 79.

PLATE **79**.

Aræosoma pyrochloa A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 78.
Natural size.



Heliotype Co Boston.

Plate 80.

Plate 80.

Aræosoma pyrochloa A. Ag. and Cl.

1. Actinostome and base of corona. $\times$ 1.3.
2. Abactinal system. $\times$ 2.
3. Actinal ambulacral and interambulacral plates, nine millimeters from ambitus. Slightly reduced.
4. Abactinal ambulacral and interambulacral plates, nine millimeters from ambitus. Natural size.


1
4
3
2

PLATE 81.

Plate 81.

1, 2, 5, 6. **Aræosoma Owstoni** Mortens., **juv.**

1. Abactinal view of partly denuded specimen.
2. Actinal view of same.
5. Abactinal view of partly denuded very young individual.
6. Actinal view of same.

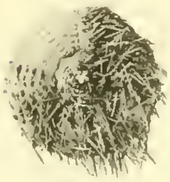
3, 4. **Aræosoma gracile** A. Ag. and Cl., ? **juv.**

3. Abactinal view of partly denuded specimen.
4. Actinal view of same.

All figures natural size.

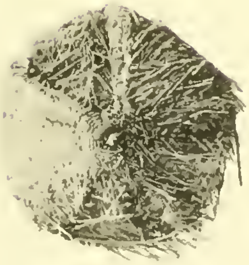
2

1

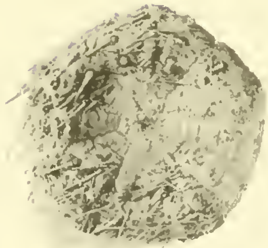


6

5



4



3

Heliotype Co Boston

Plate 82.

Plate 82.

1–4. **Aræosoma Owstoni** Mortens., juv.

1. Actinostome and base of corona of young individual shown in figures 5 and 6, Plate 81. × 5.
2. Abactinal system of same. × 5.
3. Actinal ambulacral and interambulacral plates, just below ambitus. × 5.
4. Abactinal ambulacral and interambulacral plates, just above ambitus. × 5.

5–8. **Aræosoma gracile** A. Ag. and Cl., ? juv.

5. Actinostome and base of corona of individual shown in figures 3 and 4, Plate 81. × 4.
6. Abactinal system of same. × 5.
7. Actinal ambulacral and interambulacral plates, just below ambitus. × 4.
8. Abactinal ambulacral and interambulacral plates, just above ambitus. × 5.

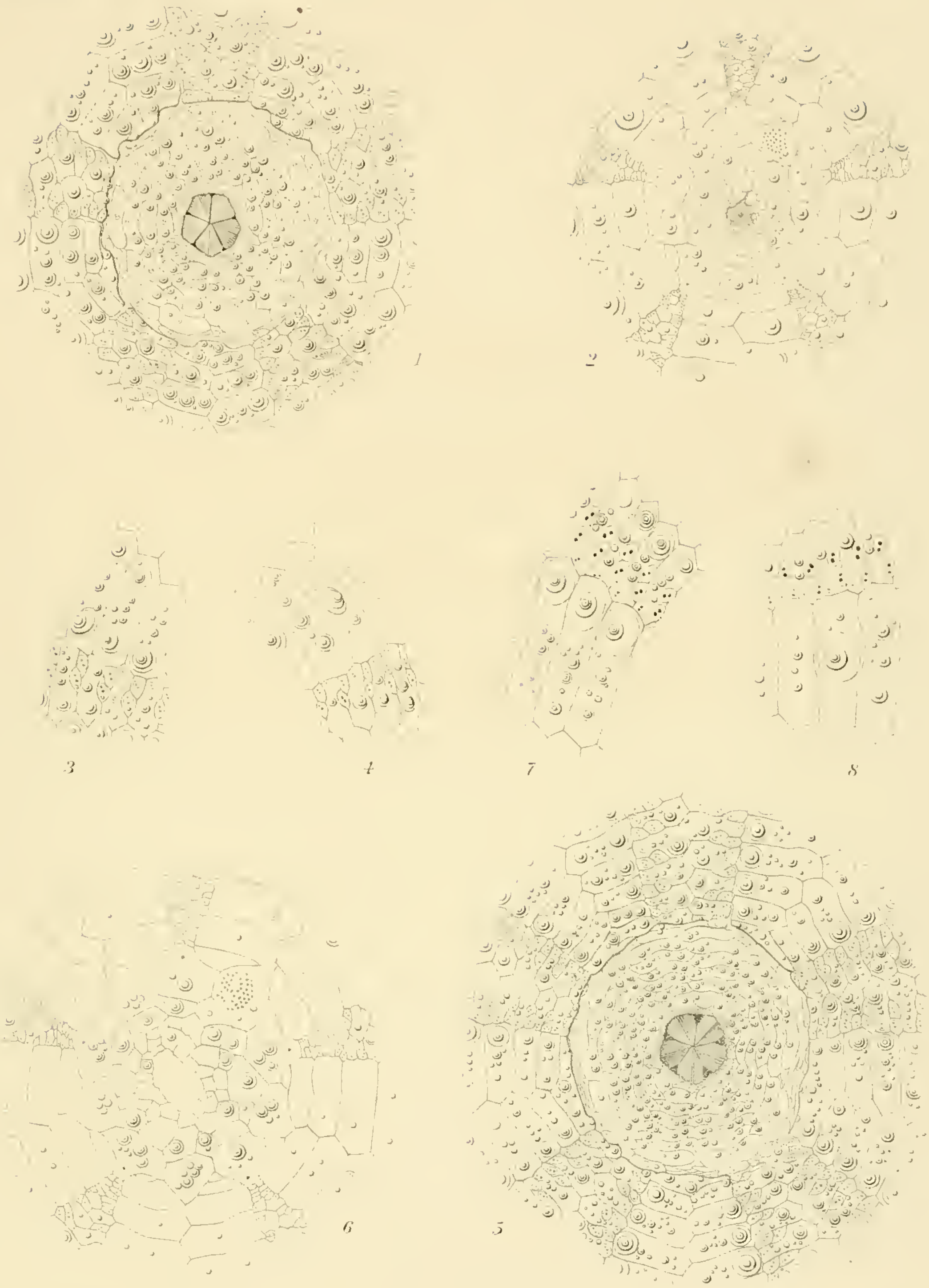

1
2
3
4
7
8
6
5

PLATE 83.

Plate 83.

Sperosoma giganteum A. Ag. and Cl.

Abactinal view of partly denuded specimen.
About two-thirds natural size.

Heliotype Co Boston.

PLATE 84.

PLATE 84.

Sperosoma giganteum A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 83.
About two-thirds natural size.

Heliotype Co Boston.

Plate 85.

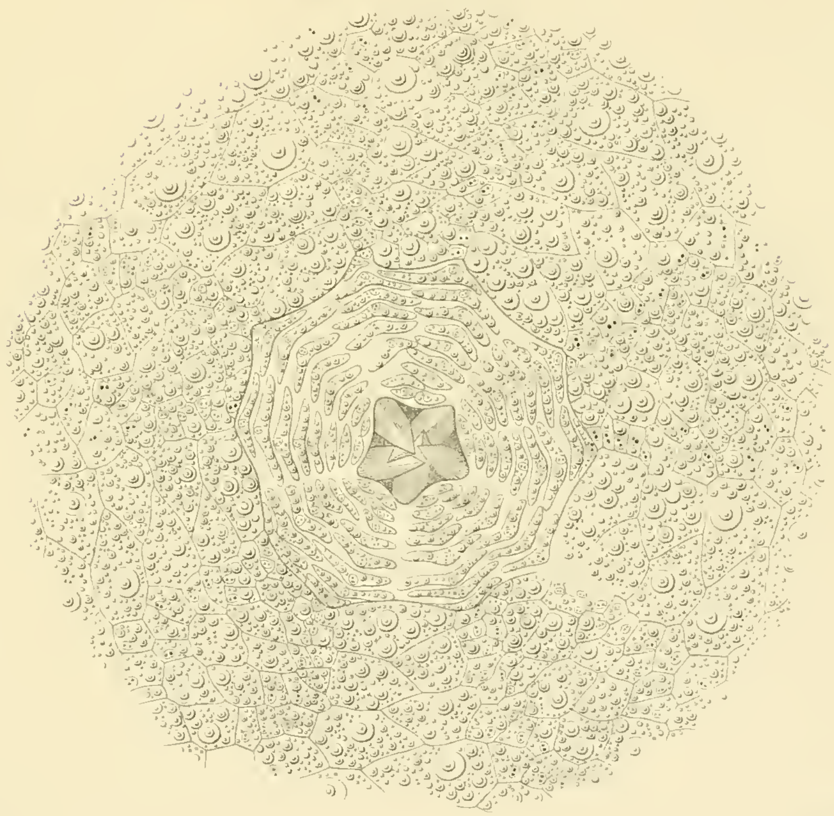
Plate 85.

Sperosoma giganteum A. Ag. and Cl.

1. Abactinal system. $\times$ 1.5.
2. Actinostome and base of corona. Natural size.

1

2



A.M W[illegible]gren del.

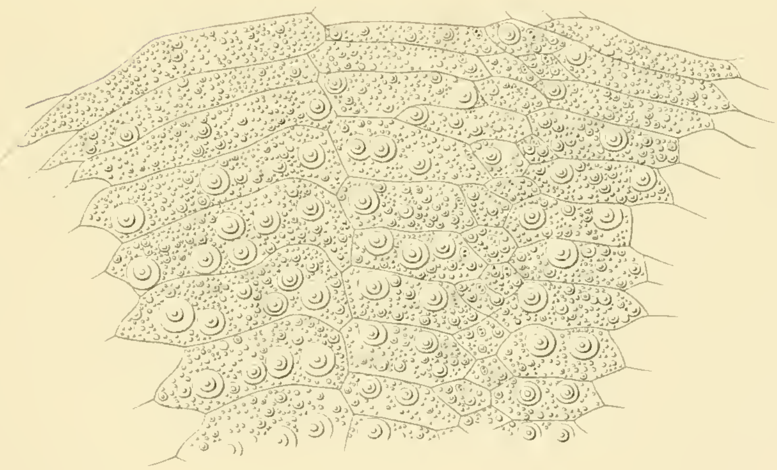
PLATE 86.

Plate 86.

Sperosoma giganteum A. Ag. and Cl.

1. Actinal ambulacral and interambulacral plates, three millimeters below ambitus. Natural size.
2. Abactinal ambulacral and interambulacral plates, ten millimeters above ambitus. Natural size.

2



1

M.Westergren del.

Plate 87.

PLATE 87.

Sperosoma obscurum A. Ag. and Cl.

Abactinal view of partly denuded specimen.
Natural size.

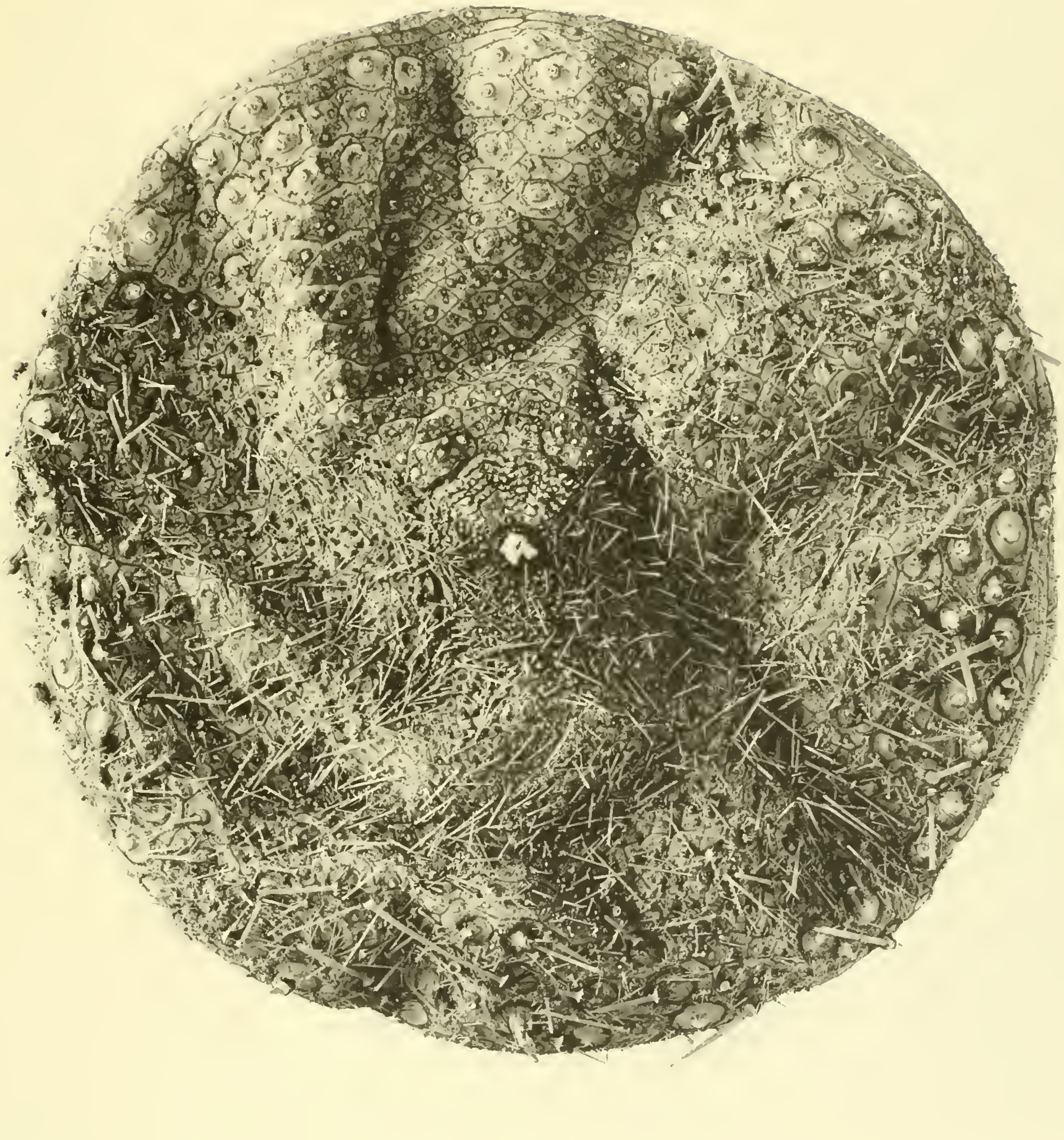
Heliotype Co. Boston.

PLATE 88.

Plate **88**.

Sperosoma obscurum A. Ag. and Cl.

Actinal view of same specimen as that shown on Plate 87.
Natural size.



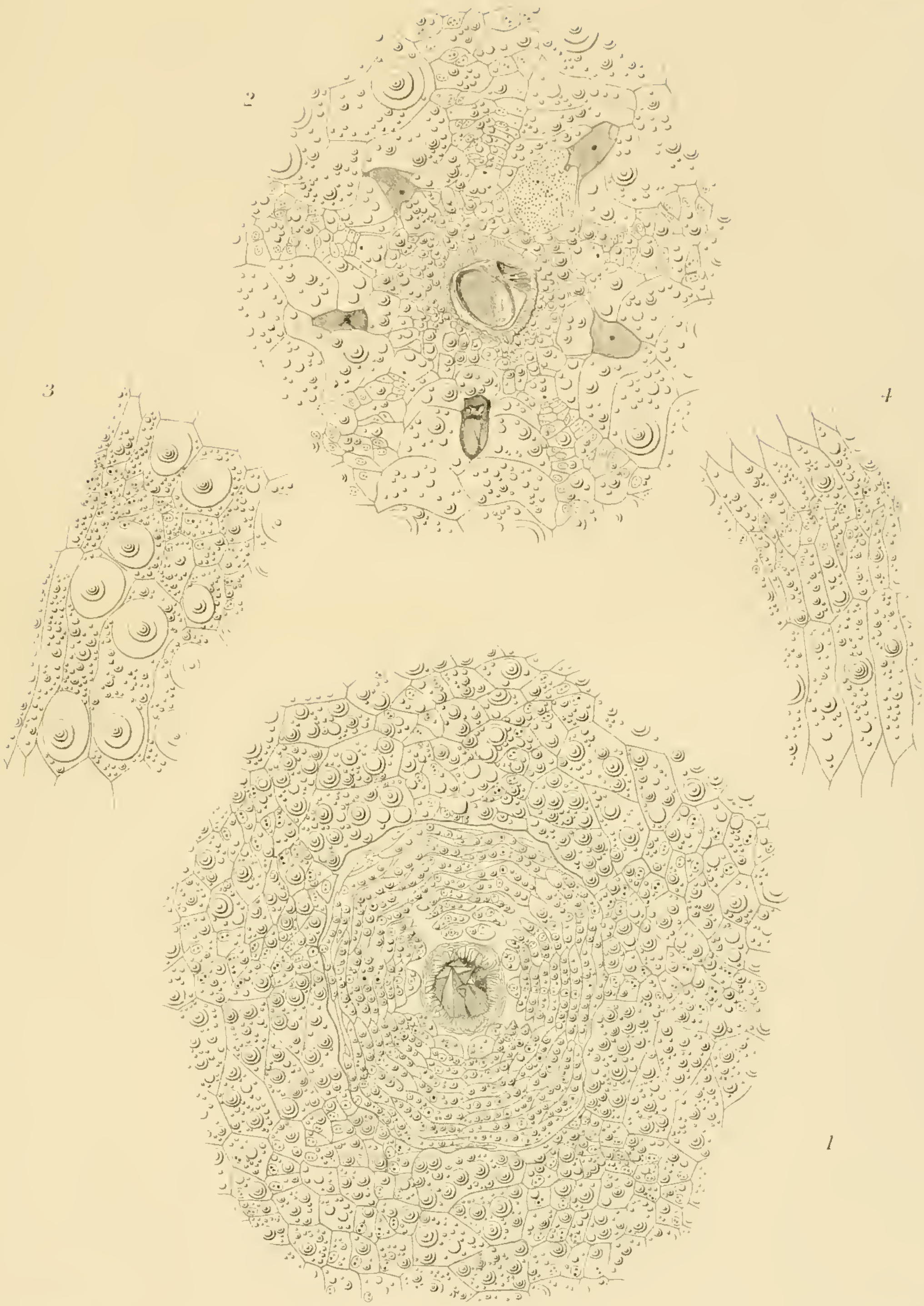
Heliotype Co Boston.

PLATE 89.

Plate 89.

Sperosoma obscurum A. Ag. and Cl.

1. Actinostome and base of corona. × 2.
2. Abactinal system. × 2.
3. Actinal ambulacral and interambulacral plates, just below ambitus. × 1.3.
4. Abactinal ambulacral and interambulacral plates, just above ambitus. × 1.2.



M. Westergren del. B. Meisel lith. Boston